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NOTES ON THE GENUS *LYGODIUM* SW. (SCHIZAEACEAE) IN MALAYSIA

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Key words: pteridophytes, Schizaeaceae, *Lygodium*, Malaysia

ABSTRACT

Ten species of *Lygodium* are enumerated for Malaysia. Of these ten species, *L. auriculatum* and *L. polystachyum* were not recorded for Sabah and Sarawak, and *L. merrillii* was not recorded for Peninsular Malaysia.

INTRODUCTION

Lygodium is a pantropical genus comprising c. 40 species. It also occurs in temperate regions (South Africa, U.S.A, Japan, Chile, and New Zealand). Holttum (1959) treated the genus in the family Schizaeaceae. The plants are twining climbers mainly in secondary forest. Fronds of young plants of *Lygodium* are dichotomously branched, but later fronds develop into a series of alternate unequal dichotomies. The rachis-branches are variously branched and bear leaflets with the sporophores at the ends of their veins. Fronds of larger species may climb to a height of 9-10 m.

In the comprehensive account of the genus *Lygodium* Sw. in the Malay Peninsula, Holttum (1955) listed seven species, namely, *L. borneense* Alderw., *L. circinnatum* (Burm. *f.*) Sw., *L. flexuosum* (L.) Sw., *L. longifolium* (Willd.) Sw., *L. microphyllum* (Cav.) R. Br., *L. polystachyum* Wall. ex T. Moore and *L. salicifolium* C. Presl. The genus was revised by Holttum (1959) for Flora Malesiana and a total of 14 species were recognised including the seven species listed above in the Malay Peninsula.

For Borneo, Holttum (1959) recognised eight species, namely, *L. microphyllum, L salicifolium, L. flexuosum, L. borneense, L. longifolium, L. circinnatum, L. merrillii* Copel. and *L. auriculatum* (Willd.) Alston. The last two species were only recorded from Sarawak and Kalimantan, respectively. Recently, *L. japonicum* (Thunb.) Sw. was recorded from Sabah, probably introduced from the Philippines (Shim, 1992). This brings the total number of *Lygodium* species in Malaysia to ten as listed in Parris & Latiff (1997).

RESULTS

KEY TO THE *LYGODIUM* SPECIES IN MALAYSIA
(modified from Holttum, 1959)

1. ***Lygodium auriculatum*** (Willd.) Alston; Holttum, Fl. Males. ser. II, Vol. 1 part 1 (1959): 54-55, f.11a-b.

1a. Secondary rachis-branches pinnate with leaflets 10-15 on each side. Sterile leaflets pinnatifid — 9 *L. polystachyum*

1b. Secondary rachis-branches pinnate with fewer leaflets. Sterile leaflets simple, palmate or lobed at base — 2

L. polystachyum
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2a.	Venation of sterile leaflets reticulate	**7. *L. merrillii***
2b.	Venation of sterile leaflets free	3
3a.	Primary rachis branches 4-10 mm long, rhizome wide creeping	4
3b.	Primary rachis branches very short (below 3 mm), rhizome short	5
4a.	Base of leaflets articulate	**8. *L. microphyllum***
4b.	Base of leaflets not articulate	**5. *L. japonicum***
5a.	Secondary rachis branches regularly pinnate with 3-5 leaflets on each side of the axis	6
5b.	Secondary rachis branches simple or dichotomously branched, leaflets simple or palmately branched	7
6a.	Leaflets all equal and stalked, not auricled or branched at the base	**10. *L. salicifolium***
6b.	Lateral leaflets larger towards base of secondary branch, smaller distal ones sessile, basal ones stalked	**4. *L. flexuosum***
7a.	Leaflets strongly cordate on outer side at base	**1. *L. auriculatum***
7b.	Leaflets not strongly cordate on outer side at base	8
8a.	Secondary branches once forked, leaflets simple. Spores smooth	**2. *L. borneense***
8b.	Secondary branches at least twice forked, leaflets often deeply lobed to palmate. Spores verrucose	9
9a.	Margins of sterile leaflets serrate. Spores irregularly verrucose	**6. *L. longifolium***
9b.	Margins of sterile leaflets entire. Spores evenly verrucose	**3. *L. circinnatum***

Representative specimens examined: **MALAY PENINSULA**: JOHOR, Mawai, *Razali Jaman RJ 1639* [UKMB]; Sedili, Sg, Tementang *Holttum s.n.* [SING]. **BORNEO**: SABAH, Tabin, *Aziz Bidin & R. Jaman AB 3557* [UKMB] and SARAWAK, Kuching, *Allen B.E.G 1671* [SING].

3. Lygodium circinnatum (Burm. *f.*) Sw.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 58-61, f. 14 a-d; Holttum, Fl. Malaya II Ferns (1968): 55, 57 , f. 9.

Distribution: Sri Lanka, NE India to Southern China, Thailand, through Malesia to Australia.
Lowland secondary forest in open places.
Representative specimens examined: **MALAY PENINSULA**: NEGERI SEMBILAN, Pasoh, *A. Samad s.n.* [UKMB]; PAHANG, Taman Negara, *Aziz Bidin & Razali Jaman AB 1693* [UKMB]; PERAK, Ulu Temango, *Ridley 14242* [SING], Pulau Pangkor, *Razali Jaman et al. RJ 3062* [UKMB]; MELAKA, *Alvins 1839* [SING]. KELANTAN, Kampung Parit, *Haniff & Nur SFN 10236* [SING]. KEDAH, Kedah peak, *Haniff & Nur 4187* [SING]. SELANGOR, Lagong hills, Kepong, *Sinclair 10721* [SING]. **BORNEO**: SABAH, Danum Valley Rain Forest, *Razali Jaman RJ 3864* [UKMB]; Beluran, Sg. Tahid, *Amin Francis 67348* [SAN]. SARAWAK, Bt. Buan, Tatau, *Perseglove, J.W. P5478* [SING]; Sg. Ringgit, Semantan, *Awang Enjah et al. S 80999* [SAN].

4. *Lygodium flexuosum* (L.) Sw.; Holttum, Fl. Males. ser. II, Vol. 1 part 1 (1959): 52-54, f. 9 e-f; Holttum, Fl. Malaya II Ferns (1968): 57-58, 629, f. 11.

Distribution: Sri Lanka, from Himalaya to southern China, Hong Kong, Riu Kiu Isl., south and south-east to Melanesia and northern Queensland, throughout Malesia.
In open places, climbing on shrubs.
Representative specimens examined: **MALAY PENINSULA**: PAHANG, Taman Negara, Ulu Tembeling, *Aziz Bidin AB 1697* [UKMB]; NEGERI SEMBILAN, Pasoh, *A. Samad s.n.* [UKMB]; TERENGGANU, Abu Talib Othman 3 [UKMB]. **BORNEO**: SABAH, Papar, Kg. Kayou, *Terence Amandus 139* [UKMB]. SARAWAK, Niah, *Ahmad 38* [SAR]; Santubung, *Carrick, J.E. JC 200* [SING].

5. *Lygodium japonicum* (Thunb.) Sw.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 50-51, f. 8 d-e; Shim, Sandakania 1(1992): 11, f.1.

Distribution: Sri Lanka, from Himalaya to Chekiang in N. China, Korea, Japan and southwards to Thailand and Indochina and southern China, naturalized in Florida and Texas, in Malesia occurring in Banka, Central and east Java, Sulawesi, Borneo (Sabah), Philippines, Moluccas, Lesser Sunda Isl. and New Guinea.
Climbing in secondary forest.
Representative specimen examined: **BORNEO**: SABAH, Sandakan, *Anon 79622* [SAN].

6. *Lygodium longifolium* (Willd.) Sw.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 56, 59, f. 12 a-c; Holttum Fl. Malaya II Ferns (1968): 55-56, 629. Syn. *L. digitatum* C. Presl.
Distribution: Southern India, Hainan, Malaya, Riouw and Lingga Isl., Sumatera and Borneo.

Ecology: Open exposed places at forest edges.
Representative specimens examined: **MALAY PENINSULA**: KEDAH, Kedah Peak, *Aziz Bidin et al. AB 2053* [UKMB]; PERAK, Pulau Pangkor, *Lagani Sahid LS 16* [UKMB]; JOHOR, G. Ledang, *Aziz Bidin AB 1596* [UKMB]; PAHANG, Taman Negara, *Aziz Bidin AB 1631* [UKMB]. **BORNEO**: SABAH, Labuk & Sugut, Bkt. Tangkunan, *Razali Jaman RJ 3618* [UKMB]; Sandakan, *Julius et al. 124277* [SAN]. SARAWAK, Kuching, *Sinclair & Kadim 10337* [SAR].

7. *Lygodium merrillii* Copel.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 60-61, f. 15a-c.

Distribution: China (Kweichow), Vietnam (Tonkin), Sumatra, Sarawak and Philippines.
Lowland and hill dipterocarp forest from elevation of 120 - 1020 m.
Representative specimens examined: **BORNEO**: SABAH, Lahad Datu, Danum Valley; W7S5 Trail, near stream. *R. Jaman, RJ 2395* [UKMB]. Keningau: Crocker Range, Batu 12, *Aziz Bidin AB 2847 & AB 2854* [UKMB]. SARAWAK (cited by Holttum,1959).

8. *Lygodium microphyllum* (Cav.) R. Br.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 47-51, f. 7 a-d; Holttum, Fl. Malaya II Ferns (1968): 57-58, 630, f. 12. Syn. *L. scandens* Sw.

Distribution: Tropical Africa, S.E. Asia, Melanesia, Australia and Malesia.
Climbing on woody plants in open places.
Representative specimen examined: **MALAY PENINSULA**: SELANGOR, Banting, *A. Samad s.n.* [UKMB]; JOHOR, G. Pulai, *Aziz Bidin AB 1593* [UKMB]; PERAK, Taiping, *Aziz Bidin AB 2173* [UKMB]; TERENGGANU, Dungun, *Umi Kalsom Yusuf UK 89* [UKMB]; MELAKA, Teluk Mas, *Ahmad Zainuddin AZ 4092* [UKMB]; PAHANG, Fraser Hill, *Haja Maideen HM 894* [UKMB]. **BORNEO**: SABAH, Tambunan, *Abdu Muhd AM 54* [UKMS], Kota Belud, Kiau Nuluh, *Jusimin Duaneh 333* [KEP]. SARAWAK, Miri, Kelabit, *Razali Jaman RJ 430* [UKMB].

9. *Lygodium polystachyum* Wall ex T. Moore.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 46-47, 50, f. 8 a-c; Holttum, Fl. Malaya II Ferns (1968): 56-57, f. 10.

Distribution: Assam, Burma, Thailand, China (Yunnan), Indochina and Malay Peninsula.
Lowland forest and on limestone.
Representative specimen examined: **MALAY PENINSULA**: KEDAH, Kedah Peak, *Aziz Bidin AB 2003* [UKMB]; PAHANG, Taman Negara, *Aziz Bidin AB 1600* [UKMB]; Sg. Tembeling, *Parris & Edward 10392* [KEP].

10. *Lygodium salicifolium* C. Presl.; Holttum, Fl. Males. ser. II, Vol.1 part 1 (1959): 51-53, 57, f. 13 a-b; Holttum, Fl. Malaya II Ferns (1968): 57-58, 629-630. Syn. *L. flexuosum sensu.*

Distribution: Malaya, Sumatera, Borneo and Talaud Isl.
Swamp forest in open places.
Representative specimens examined: **MALAY PENINSULA**: JOHOR, Sg. Dohol,

Razali Jaman RJ 1641 [UKMB]; PAHANG, Taman Negara, *Aziz Bidin AB 1604* [UKMB]; KELANTAN, Gua Musang, *Razali Jaman RJ 1968* [UKMB]. **BORNEO**: SABAH, *Kadim A 2723* [SAN]. SARAWAK, Marudi, Sg. Melinau, *Nielsen, I. 433* [SAR].

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BOOK REVIEW

CRYPTOGAMS: FERNS AND FERN ALLIES. PLANT RESOURCES OF SOUTH-EAST ASIA 15(2). De Winter, W.P. and Amoroso, V.B. (eds.). 2003. Backhuys Publishers, Leiden, The Netherlands. 268 pp. ISBN 90-5782-128-1. Price $99.

Twenty-three authors from South-East Asia and Europe contributed to this fifteenth volume in the PROSEA series that aims at dispersing the knowledge on plant resources in SE Asia. The book consists of three chapters: an introduction to pteridophytes, a treatment of 14 selected pteridophyte genera and 39 species, and a combined chapter on bryophytes (two genera and one species example). The chapter on mosses is added because it would be too small to substantiate a separate volume. The introduction chapter (1) is clear and covers wide aspects of pteridophytes from uses, phyto-chemistry, morphology, ecology, to propagation. Some aspects, e.g. on ecology, are rather simplified but it is perhaps appropriate in this context. The figures have been redrawn and are clear, uniform and illustrate nicely the examples given. However, the numbers on sub-figures are often in a confusing order and could easily have been arranged more logically. Unlike the usual format of Prosea, this volume uses the criterion of any publication mentioning usefulness of a pteridophyte. However, Table 1 still gives an overview of 18 categories of uses including medicinal, ornamental, food, etc. covered by the examples of species and genera that forms the bulk of the content with 53 individual papers. Each contribution follows the same format and gives information on taxonomy, ecology, uses, names, propagation, literature etc. Unfortunately, the important work by Hanne Christensen (1997, 2002) in Sarawak, Borneo, has escaped the attention of the authors. She documented several species and genera which unfortunately are not mentioned in the PROSEA volume. For example the use of *Sticherus truncatus* as an important fibre plant for two tribes in Borneo. Other genera not mentioned are *Hymenophyllum* with medicinal uses, *Sphenomeris chinensis* as a tranquilizer, and several genera and species in the Thelypteridaceae used as vegetables.

In conclusion, the volume manages to present the more than 4000 South-East Asian ferns, fern allies, and mosses in a very attractive and easily accessible format. Most of the examples of useful plants are typical, relevant and informative but as the compilation was based only on literature available to the authors, there are apparently still more useful pteridophytes in South-East Asia to be mentioned or documented in the future.

Axel Dalberg Poulsen

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HENRY BRADBURY'S FIRST NATURE-PRINTS OF FERNS

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Key words: Bradbury, Baildon, ferns, nature-prints

ABSTRACT

Although Henry Bradbury's Nature-Prints of ferns in Moore (1855/56) and Moore (1859/60) are well-known to pteridologists, his earlier prints, some of which are also of ferns, are rarely seen. Most of these were published (Bradbury, 1854) as sets of prints, mostly of flowering plants but also including five prints of ferns, issued unbound without text. Eleven sets have been located, mostly in institutional libraries. Together they include 39 different Nature-Prints but no set contains more than 33 prints and most sets differ in the number and choice of prints. To give a full description of this publication, it is necessary to describe all the available sets. Some sets include a title page, which was produced in two different versions. Four identical sets of 33 prints have a numbered list of plates. Nine of the examined sets were published by Bradbury & Evans in London; two appear to have been re-issued in 1867 by Baildon of Edinburgh. Also described is an unpublished fern Nature-Print, possibly pre-dating all the others.

INTRODUCTION

Many fern enthusiasts will know of the remarkable imperial-folio size Nature-Prints by Henry Bradbury, 51 in total, that illustrate "*The Ferns of Great Britain and Ireland*" with text written by T. Moore and edited by J. Lindley (Moore, 1855/56; Figs 1, 2, 3). Henry Bradbury's technique was the culmination of several centuries of development of nature printing. He took an impression of a dry plant specimen in a lead plate, made an electrolytic copper replica of the lead impression, and then hand-inked the intaglio copper plate in colours (Cave and Wakeman, 1967; Heilmann, 1988; Wakeman, 1966). The life-like fern images thus produced are striking examples of what can be achieved by this method, although Harris (1970) points out that the copper plates were touched up with burin and punch to make the detail clearer. The folio ferns were issued in 17 parts between March 1855 and October 1856; the parts cost 6s. (£0.30) each, and the whole volume cost 6 guineas (£6.30), equivalent to about £300 today. The author's preface is dated July 14, 1856, but in most of the copies that I have seen, the title page is dated 1855. However, the copy in the Wellcome Library, London, has the date "1857" on the otherwise identical title page, indicating that there was a later re-issue, perhaps as a complete volume. Cave and Wakeman (1967) state that one part was again re-aaaaissued in 1869 but I have not been able to confirm this. Moore did write the text for a short book with four nature printed plates of ferns which was published that year (Moore, 1869) but neither Bradbury nor his technique were employed.

Perhaps even more familiar than the folio ferns are the two smaller royal-octavo volumes of "*Nature-Printed British Ferns*", also with text by Moore and illustrated by Bradbury with 122 Nature Prints (Moore, 1859/60; Figs 4, 5). Volume 1 was first published in October, 1859 and Volume 2 in June, 1860 (Hall, 1984) although both

volumes are dated 1859 on the decorative title page, which has a small fern Nature Print in a vignette. The title pages and bindings were designed by Bradbury's friend John Leighton F.S.A., a noted colour printer. Each volume cost 2 guineas (£2.10). Bradbury's technique had improved by the time that these were produced and there is no evidence of touching up (Harris, 1970). Both volumes were re-issued in 1863 in a cheap edition at £3. This later edition has the original decorative title page dated 1859 but the actual date of publication, 1863, on the main title page.

It is widely believed that the 2 works referred to above contain the only fern Nature-Prints that Bradbury published. Nigel Hall (1984) states, referring to the folio Ferns, "Nothing like this had been produced before…" and "Nature-printing, which would have been a failure if applied to flowering plants, recorded fern forms accurately and with great effect.". There is no mention of the fact that Bradbury had published Nature-Prints, of flowering plants and ferns, in 1854 before any of the books produced with Moore. He did not publish any more prints of flowering plants though shortly before he died he advertised the intention to do so (Bradbury, 1860). The fern prints confirmed the suitability of this material for his method of nature-printing, a fact that he clearly recognised. According to a report of his 1854 lecture to the Royal Institution (Anon, 1855), he stated: "Ferns, by their peculiar structure and general flatness, are especially adapted to develope (sic) the capabilities of the process, and there is no race of plants where minute accuracy of delineation is of more vital importance than the Ferns; in the distinction of which, the form of indentations, general outline, the exact manner in which the repeated subdivision is effected, and most especially the distribution of veins

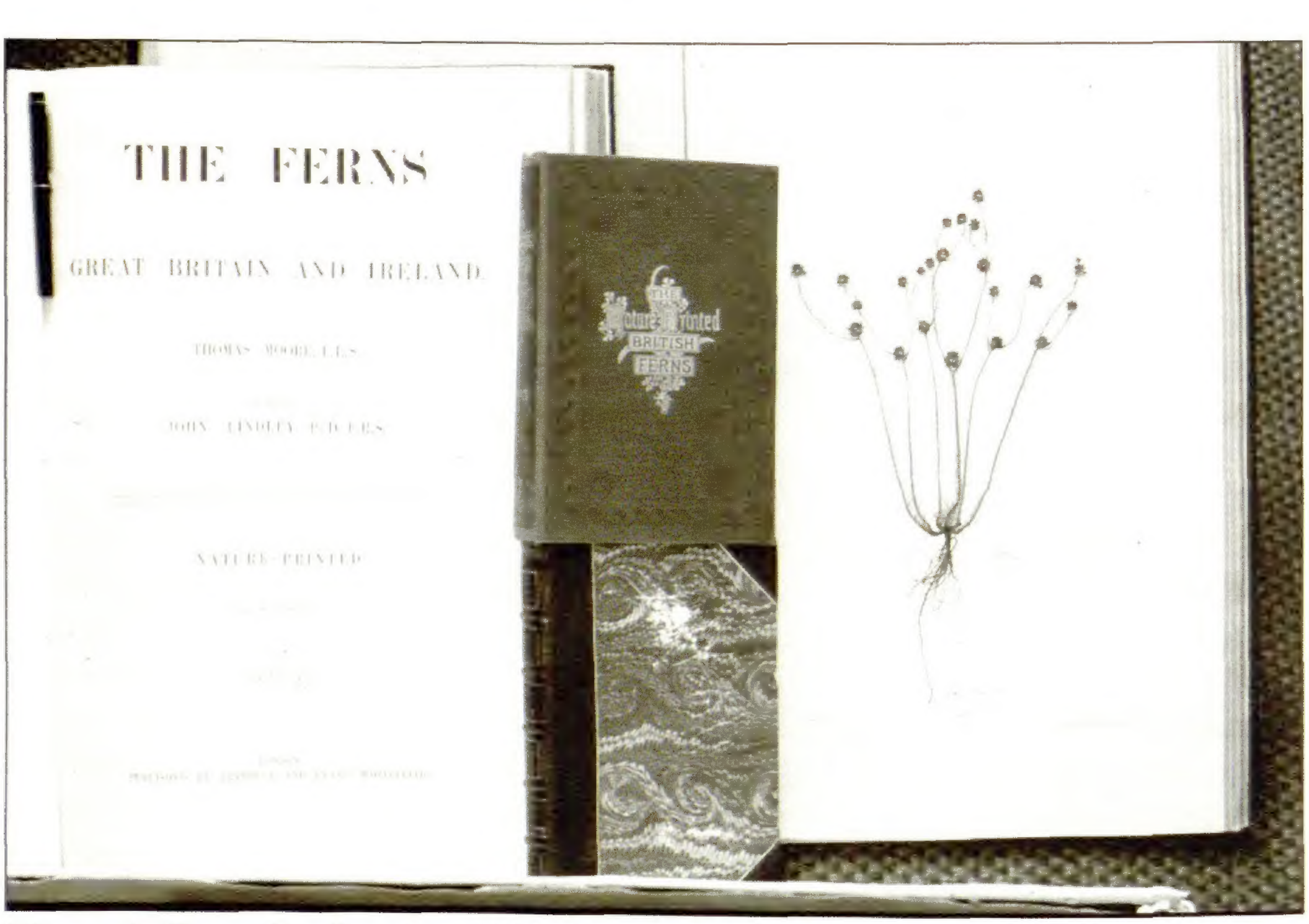

Figure 1. Henry Bradbury's published works. Left: Moore's folio "*Ferns of Great Britain and Ireland*" (1855/56); Centre Top: Moore's octavo "*Nature-printed British Ferns*" (1859/60); Centre Bottom: Johnstone and Croall's octavo "*Nature-printed British Seaweeds*" (1859/60); Right: Bradbury's folio prints "*A Few Leaves…*" (1854) (showing Plate 23, 'Common Filago').

scarcely visible to the naked eye, play the most important part". Perhaps this explains why his next publication was "*The Ferns of Great Britain and Ireland*".

The lack of awareness of the 1854 prints can be readily excused; they were not issued as a book with text, they are not widely available for consultation, and very few authors mention them (but see Cave & Wakeman, 1967; Elliott, 1993; Harris, 1970). Even Bradbury (1856,1860) makes no later reference to the 1854 prints. Nevertheless, they include some of his most striking nature-prints and they deserve to be better known. The sesquincentennial year of their publication is an appropriate time to make information about these and other early Bradbury fern prints more widely available.

UNPUBLISHED PRINTS

Henry Bradbury (c.1829-1860, Fig. 6) went to the Imperial Printing Office of Vienna in August, 1852, to observe Auer's technique for Nature-Printing. After returning from Vienna early in 1853, Bradbury introduced the technique to his father's printing firm, Bradbury & Evans, in London. In June, 1853, they took out British Patent No. 1164 for what they claimed was a modification of the method. More information about Henry Bradbury and his technique has been presented by Wakeman (1966) and Cave & Wakeman (1967).

After returning from Vienna, Henry Bradbury must have produced some trial Nature-Prints before any were published. In the absence of any surviving Bradbury & Evans archives, little is known about these early efforts. However, in the Wellcome

Figure.2. Moore's folio "*Ferns of Great Britain and Ireland*" (1855/56), Plate L '*Osmunda regalis*'.

Figure.3. Moore's folio "*Ferns of Great Britain and Ireland*" (1855/56), Plate V '*Polypodium Phegopteris*' (=*Phegopteris connectilis*)

Library there are some unpublished Bradbury Nature-Prints. One is a small print (226mm x 117mm), without a plate mark, of three flowering plants in four colours (*Meianthemum bifolium*, a crocus, and an anemone). The other print, of which there are two identical copies, is of the fern *Polystichum aculeatum*, wrongly identified in the Wellcome catalogue as *Dryopteris filix-mas*. It is unlike any of the published fern prints: it is from a different specimen, the platemark is narrow (458mm x 200mm) and contains only a single frond, and there is no plant name. On none of these prints is there a plate number. In the bottom right-hand corner of both the flowering plant and the fern print is printed "PRINTED IN COLOURS BY BRADBURY & EVANS, PATENTEES, WHITEFRIARS", as in all the published prints. At the bottom of both prints within the plate mark is printed "PHYTOGLYPHY OR THE ART OF PRINTING FROM NATURE". The term 'phytoglyphy' does not appear on any published print. Bradbury notified Auer in a letter dated December, 1853, that he had called the nature-printing process 'Phytoglyphy' (Cave & Wakeman, 1967) but he seems to have soon abandoned the term for his published work and in 1860 refers instead to "autotypography" (Bradbury, 1860). This seems to indicate that, despite the date "c.1860" in the Wellcome catalogue entry, both plates were produced early, before the 1854 publication, but after the patent was issued in 1853. These may be the earliest known Bradbury Nature-Prints. They can be seen on the Wellcome Photographic Library web site (http://medphoto.wellcome.ac.uk).

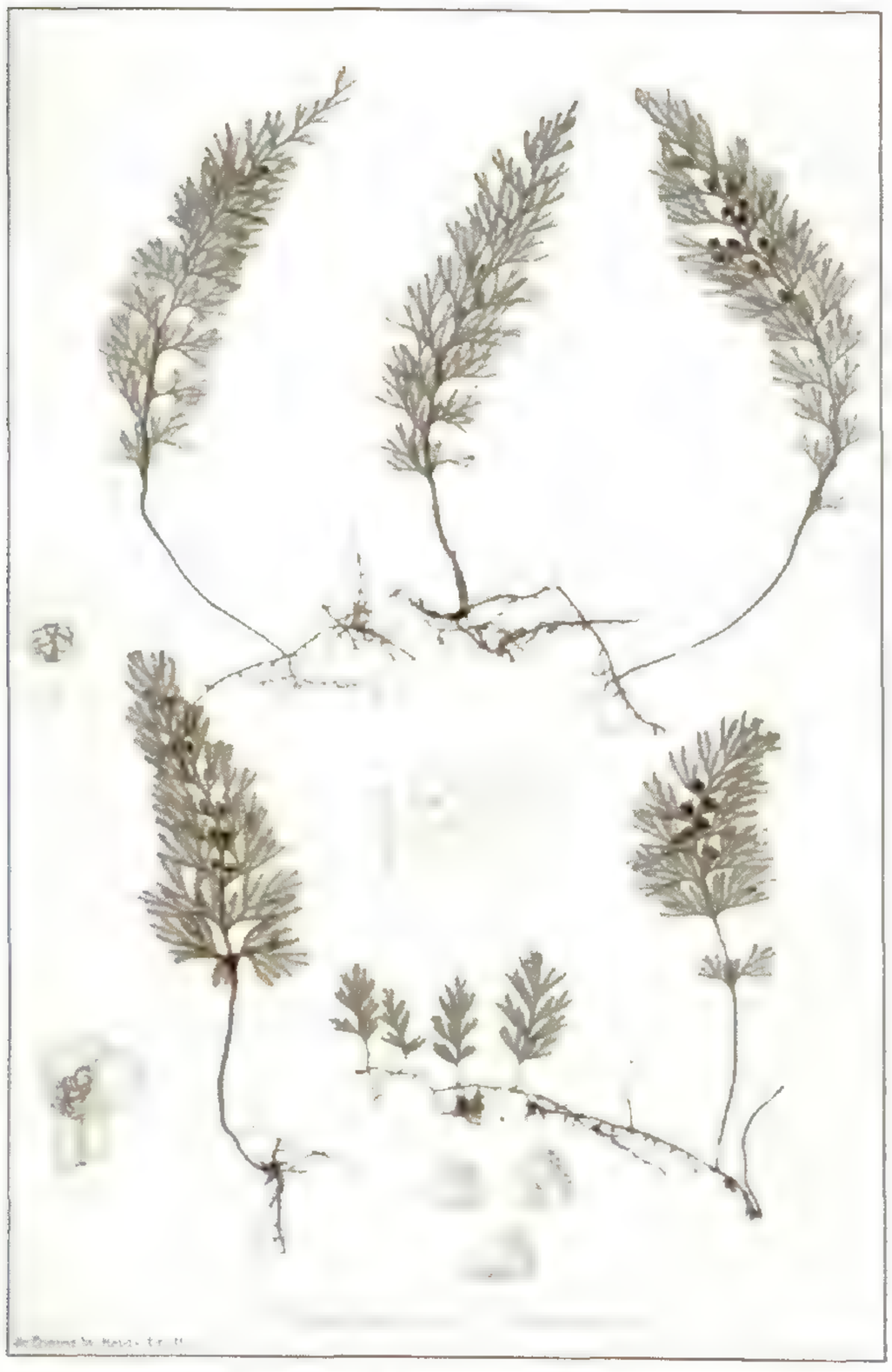

Figure 4. Moore's octavo "*Nature-printed British Ferns*" (1859/60), Plate CVIII '*Hymenophyllum tunbridgense*'.

Figure 5. Moore's octavo "*Nature-printed British Ferns*" (1859/60), Plate XIV '*Gymnogramma leptophylla*' (= *Anogramma leptophylla*).

PUBLISHED PRINTS - BRADBURY (1854)

Bradbury's first published fern Nature-Prints were issued, in 1854, as part of a set of prints with a long title beginning "*A Few Leaves*....." but no text. The page dimensions are 556mm x 368mm, approximately the same as those of the imperial-folio ferns. Wakeman (1966) refers to a 'volume' of 21 prints and Wakeman (1984) again states that 21 were issued but Harris (1970) refers to a volume containing "33 prints from wild flowers". It now seems clear that the prints were offered for sale unbound, and, as stated on the original title page, either singly at 1s 6d (7.5p) each or in sets of 21 at 1 guinea (21s, £1.05), selected from a longer list. They seem to have been considered by Bradbury as curiosities or an advertisement rather than a book. It is not known how many sets were sold or donated but Peter Heilmann (pers. com. 1988) is of the opinion that maybe only 20 or 30 sets were issued. Several libraries of botanical institutions and stately homes that I contacted do not possess a set. A survey in the late 1980s of several antiquarian booksellers in London and Edinburgh revealed that none had seen a copy in the previous 50 years, though in 2001 a set of 33 prints was offered by Marlborough Rare Books at £7500. In addition, according to Wakeman (1966), "half a leaf from '*A Few Leaves Nature Printed*'" provides an illustration in the Bodleian copy of '*The Art Exemplar*' by J.W.Stannard (c.1858).

Fig.6. A portrait of Henry Bradbury from a Bradbury & Wilkinson brochure issued in 1988 (identified by Ray Marshall. Consultant Archivist, De La Rue, pers. com., 2003, and reproduced here with permission).

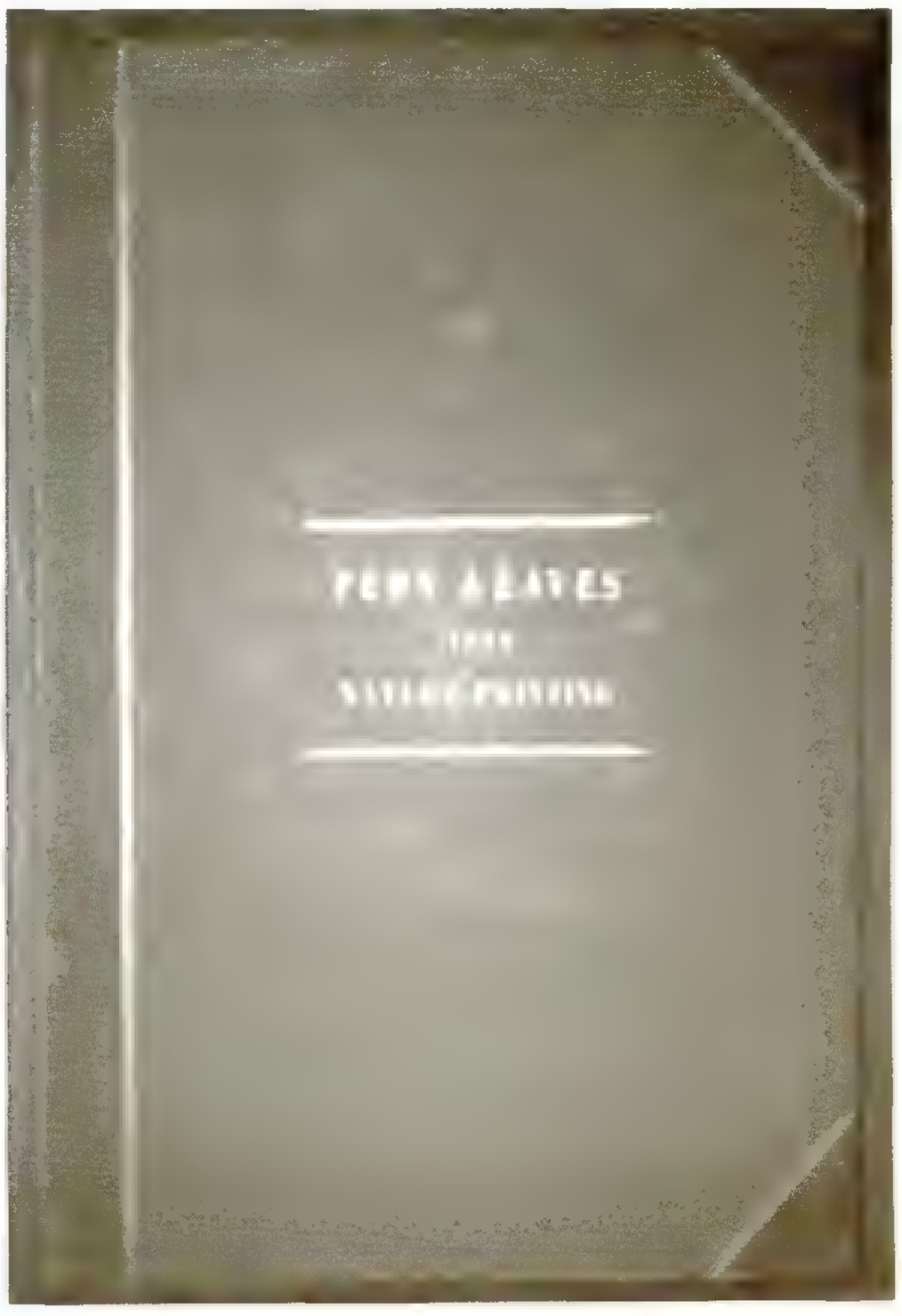

Fig.7. The cover of my copy (AFD) of Bradbury (1854). The 21 plates were apparently bound by an early owner and mistakenly titled "*Fern leaves from Nature Printing*" (instead of "*A Few Leaves*.....") despite the fact that only 3 plates are of ferns.

Research soon revealed that, although most sets contain some fern prints, there are some differences in the total number of prints and, even when the same number of prints are present, the sets frequently do not contain the same prints (Table 1). As a consequence, a full description of this publication is only possible after examination of all available sets. With the help of Caroline Marten, I have so far been able to locate 11 sets, nine of them in museums and institutional libraries. These are described for the first time below. I would welcome information from anyone who knows of other sets of these prints.

The 11 Known Sets Of Prints

The 11 sets that have been traced to date are described below. Each has an abbreviated title referring to its location: RI (Royal Institution Library, London); BL (British Library); BLO (Bodleian Library, Oxford); CUL1 (Cambridge University Library, Reference Number: MH.7.8); CUL2 (Cambridge University Library, Reference Number: CCF.47.19); PUNCH (Punch Cartoon Library and Archive, London); CUL3 (Cambridge University Library, Reference Number: Waddleton.bb.9.1.38); V&A (Victoria and Albert Museum Print Library, London); AFD (privately owned, A F Dyer);WL (Welcome Library, London); MF (privately owned in New Zealand). The prints present in each set are shown in Table 1. Prints numbered 1-33 are those present in the set (RI) given to the Royal Institution by Henry Bradbury, numbered according to the list accompanying the prints. Prints numbered (34) - (39) are those additional prints occurring in other sets.

RI

As stated by Wakeman (1966), one set of prints (RI) is held at the Royal Institution. Together with a copy of folio ferns, this set was presented to the RI by Henry Bradbury. According to a manuscript note attached, it was donated on 8 February,1855, after the prints had been first published the previous year but three months before he gave a lecture about the technique (Anon, 1855; Bradbury, 1856); perhaps he presented them in response to the invitation to speak. They were apparently donated in the loose state. The prints were bound in May, 1965, into a green cloth-covered volume with '*Nature Printing. Bradbury and Evans*' on the spine.

There are 33 prints (Table 1), most of them in good condition apart from some dirt and discoloration around the margin outside the plate mark, no doubt due to over a hundred years of handling before they were bound. There is a title page giving the full title: "*A FEW LEAVES REPRESENTED BY "NATURE-PRINTING" SHOWING THE APPLICATION OF THE ART FOR THE REPRODUCTION OF BOTANICAL AND OTHER NATURAL OBJECTS. WITH A DELICACY OF DETAIL AND TRUTHFULNESS TO NATURE UNOBTAINABLE BY ANY OTHER KNOWN METHOD OF PRINTING.*" and, under the firm's crest, the additional information: "*PRINTED AND PUBLISHED BY BRADBURY & EVANS, 11 BOUVERIE STREET, WHITEFRIARS, LONDON. MDCCCLIV. PRICE 21s.; OR SEPARATELY,1s. 6d. EACH.*". On the verso of the title page are printed "*OPINIONS OF THE PRESS*" with the headings: "*ATHENAEUM*", "*THE TIMES*", "*DAILY NEWS*", "*EXAMINER*". There then follows a page printed in the same style and headed "*NATURE-PRINTING SPECIMENS. LIST OF PLATES.*". There is little doubt that these pages were printed and supplied by Bradbury. The list of plates is numbered, but the prints themselves are not numbered although they were arranged in the same sequence when bound. The

numbering system used by Bradbury seems to be quite arbitrary and there seems to be no logic to the order (for example, ferns appear among the angiosperms at Nos 15, 20, 25, 26, and 32). These plate numbers will be used in the rest of this account for reference purposes. All the prints listed are present in the RI set and no prints are present that are not listed. At the bottom of the list of prints is the following advertisement: *"Notice. - Messrs. Bradbury & Evans beg to announce that they are preparing for publication, in Monthly Parts, a PERFECT COLLECTION of the BRITISH FERNS, accompanied by scientific and popular descriptions of all indigenous species and varieties, with instructions for their cultivation.*".

BL, BLO, and CUL1

Three other sets identical to the RI set have since been located, one at the British Library (BL), one at The Bodleian Library, Oxford (BLO) and one at Cambridge University Library (CUL1) (Table 1). All three have the same title page, press opinions and list of plates, and the prints are unnumbered but bound in the order as listed. All three are in contemporary binding, either green or brown. BL and BLO have "NATURE PRINTING" on the spine. In BL, each print has a British Museum stamp and although there is no information about its history, it is likely that it was a Copyright Act deposit. Several BL prints (e.g. Nos 2, 5, 16, 26 and 31) have clearly visible ink marks on the background where the plate surface has not been adequately cleaned before printing. Regarding CUL1, Nicholas Smith (Under-librarian, Rare Books Department, CU Library) tells me that it too was probably received under Copyright Act deposit, and according to the records was "Collated Feby 24, 1856", a year after the Royal Institution set was donated.

CUL2

Cambridge University Library has a second, unbound, set (CUL2) (Table 1), consisting of only 21 prints. It has no title page or list of plates. All the prints are represented in the list of 33 in RI. This set, previously kept in the Department of Plant Sciences, was donated in 1943 by a Miss Borrer. There maybe a connection with William Borrer (1781-1862), a highly esteemed British botanist and horticulturist, who contributed to Newman's '*A History of British Ferns*' (1840) and assembled a considerable botanical library. This set appears to be one of the sets of 21 sold to the public where the purchaser has chosen the required prints from the full list of 33.

PUNCH

The Punch Cartoon Library and Archive possesses a set (PUNCH) of 3 prints (Table 1); all 3 are also found in the RI list. They were either obtained singly or are the incomplete remnants of a larger set. Nothing of their history is known but the fact that Bradbury & Evans owned *Punch* at the time the prints were made might provide a clue.

CUL3

The third set (CUL3) owned by Cambridge University Library is particularly interesting. It consists of 33 prints, but not the same 33 as in RI, BL, BLO and CUL1. Although the five fern prints (Nos 15, 20, 25, 26 and 32) are still present, five of the flowering plant prints in RI (Nos 2, 8, 12, 22, and 24) are missing and 5 different ones (Nos (35) to (39)) have been added (Table 1). Furthermore, the title page is different: it begins with "*BY ROYAL LETTERS PATENT. A FEW LEAVES FROM THE NEWLY*

INVENTED PROCESS OF "NATURE-PRINTING". SHOWING THE APPLICATION OF THE ART FOR THE REPRODUCTION OF BOTANICAL AND OTHER NATURAL OBJECTS.". There is no Bradbury & Evans crest. At the bottom of the page, the date "*MDCCCLIV*" is the same as in RI, but "*PATENTEES*" has been inserted after "*BRADBURY & EVANS*". There are no press opinions or list of plates. It is in a contemporary binding. Bought by Cambridge University in 2001 from Marlborough Rare Books, it has an autograph of 'G.B.Rose', presumably a previous owner. It seems unlikely that Bradbury would have deposited for Copyright purposes sets that were incomplete at the time, so CUL3 may be a later set than BL *et al.*. The title page appears to have been produced after the Patent had been granted (in June, 1853) though still in 1854. The presence of additional prints suggests that CUL3 was assembled after the RI set was donated in February 1855. It might also have been a presentation copy but is unlikely to have been deposited for later Copyright purposes because it was in private hands at a later date. Why it contained the same, apparently arbitrary, number (33) of prints as RI, BL, BLO and CUL1 after additional plates had been made is less clear.

V&A

The Victoria & Albert Museum print collection contains a set (V&A) of 21 prints (Table 1). They are unbound but individually mounted. There is a loose title page, which is the same as CUL3, but no list of plates. They are numbered for the V&A catalogue but the sequence is not taken from the RI list. The prints include one (No.(35)) which is in CUL3 but not in RI, and one print (No.(34)) that is in neither. Thus it becomes clear that at least 39 different prints were produced. The title page links this set to CUL3. V&A appears to be another privately purchased set of 21, this time chosen from a list including prints not present in RI.

AFD

Another set (AFD) was the first one I saw. I bought it in 1986. I had seen an advertisement for "Two large illustrated fern books" in the Personal Column of the Institute of Biology journal "*Biologist*". Enquiries by telephone revealed that a private girl's school in Sussex was selling the books, which had been found at the back of a cupboard, to raise funds for equipment for the biology laboratory. From the description, one was clearly the folio "*Ferns of Great Britain and Ireland*". The other was described as a book of similar size and binding called "*Fern Leaves from Nature Printing*". A meeting was arranged in a conveniently located pub, where my suspicion that, despite the different title, the second book was a copy of Bradbury (1854) was confirmed, and a transaction rapidly completed.

AFD contains 21 prints (Table 1), one of which is not in RI. It is in a contemporary binding (Fig. 7) but there is no title page. When the set was bound, probably by the first owner, the title was incorrectly stated on the outside of the front cover. It is titled "*Fern Leaves.....*" instead of "*Few Leaves...*" despite the fact that only 3 of the prints are of ferns. The prints are not bound in the same sequence as in the RI set. Labels inside reveal that at some time before 1939 this volume had been through the hands of H M Gilbert, Booksellers of Southampton and had been bought on 1 November 1947 by Varndean Field Club. Unfortunately, as in some other sets, a few of the prints are badly foxed. There is one print (No.(35)) that is also present in CUL3 but not in RI. Like V&A, AFD appears to be a privately purchased set of 21 prints chosen from the longer (and later?) list. It is interesting to note that Print Nos 12 and 22, absent from CUL3,

were still available when AFD was first bought.

WL and MF

The two other sets that have been located differ from all the rest in two significant respects. Each set consists of 14 prints, and in the bottom left hand corner of each print under "*Nature Printing*" are printed the word "*Plate*" and a number. Otherwise every print is identical to a print in one or other of the sets described above. The engraved plate numbers on the print do not coincide with the numbers of the corresponding plates in the RI list, nor are they in the same sequence.

One set (WL) (Table 1) is in the Wellcome Library, London. The prints can be viewed on the Wellcome Photographic Library website, Photo nos 43911 to 43924. This set does not include a fern print. WL is unbound and there is no title page or list of plates. All the prints have been trimmed to the plate mark by cutting or tearing. The paper is similar if not identical to that used in the other sets. One of the prints (No.(37)) is not included in RI but is in CUL3. The engraved plate numbers are not in a continuous sequence and range from 1 to 23. The Wellcome Library catalogue states: " Imprint - [Edinburgh c. 1867] (London : Bradbury & Evans, patentees, Whitefriars)" and " Note - Plate to: Baildon, [Nature printing], Edinburgh, c.1867". The exact significance of these notes is not clear but the librarian was unable to locate any other information on a connection with Baildon and Edinburgh, or to establish the source of the information in the computer records. Henry Craven Baildon (1806-1881) was a leading Edinburgh pharmacist with a pharmacy at 73, Princes Street. He published accounts of the medicinal properties of certain plant extracts but he clearly also had interests in printing. He patented a secure process for crossing banker's drafts and on May 15,1867, registered a patent (No.1432) for a method of nature printing from ferns and other plants. This method was quite distinct from Bradbury's and involved chromolithography: the impression was taken on transfer paper direct from the frond and transferred onto a lithographic stone for printing. In 1869, he produced from his Edinburgh address "*Baildon's Nature-Printed Ferns*" (Moore, 1869), published by L.Reeve & Co. London and printed in Edinburgh. This has 4 chromolithographic prints of an assortment of 12 exotic species and native varieties, and text by Thomas Moore. Clearly, Baildon had an interest in nature printing, especially of ferns, during the 1860s and would have been aware of Bradbury's earlier publications. He might well have made an arrangement with Bradbury & Evans after Henry Bradbury's death in 1860 to re-issue "*A few leaves...*" before developing his own method, although there is no confirmation of this among the Bradbury & Evans correspondence held in the Bodleian Library. Perhaps it was Baildon who decided to add the plate numbers and make the prints available to the public in sets of 14 chosen from a longer list. The prints are so similar to the other sets, apart from the added plate numbers, that it is hard to believe that they were not also printed by Bradbury & Evans using the original plates, or new copper replicas of the same original lead impression. If on the other hand they were printed in Edinburgh, the original process must have been replicated exactly. This is the only indication of a second issue of the Bradbury (1854) prints.

The last of the 11 sets (MF, Table 1) known to me is privately owned in New Zealand, where it was taken in 1880. It is unbound. I have seen 6 prints (Nos 7, 11, 13, 16, (34) and (36)); the owner provided the full list of 14. MF contains 4 prints ((34), (36), (37), (38)) not in RI but in either CUL3 or V&A. Like WL, this set also lacks fern prints but it does not contain the same 14 flower prints. Plate numbers of MF (absent

from one print, probably due to damage) range from 2 to 31. Four prints (Nos 7, 10, 11 and 16) are common to both WL and MF and have the same engraved plate numbers. Close, detailed, comparison of prints and paper from AFD and MF (Nos 7, 11 and 13) revealed no detectable differences other than some small variations in ink density. MF thus appears to be another set of 14 prints, with added plate numbers, chosen by the original purchaser from a list of at least 31. It is likely to have the same origins as WL.

It is not possible to deduce from the available information whether the lack of fern prints in WL and MF is because the ferns had been removed from the list of available prints or because both the purchasers chose only flowering plants.

The 39 Known Nature-Prints Comprising Bradbury (1854)

In all of these sets, the prints differ from all Bradbury's later published Nature-Prints in that there is a distinct plate mark, the dimensions of which vary between plates. In the later prints (Moore, 1855/56, 1859/60), either the plate was larger than the paper or the plate mark was removed.

There are some curious minor differences between the 39 prints. Most have at the bottom of the Plate, within the plate mark: "*Nature Printing*" in several different fonts in the left-hand corner; then the family, Latin name and common name of the specimen in the middle, and then "*PRINTED IN COLOURS BY BRADBURY & EVANS, PATENTEES, WHITEFRIARS, LONDON.*". One plate (No.3), of *Chelidonium majus*, is in 'landscape' format, the remainder in 'portrait'. (There are no landscape plates in Moore, 1855/56). Five prints (Nos 3, 5, 20, 26 and 32) differ in having the Family name at the top; 3 of these prints are of ferns but there is nothing else that obviously links any of the five prints involved. One other print (No. 15) has all the other names as well as the family name at the top; it is again a fern and this positioning may simply be to accommodate the folded frond (Fig. 8). Finally, four prints (Nos 3, 10, 21, and 24) have "*colors*" instead of "*colours*"; again there is no obvious link between the four.

Of the total of 39 plates, 5 are of ferns (Nos 15, 20, 25, 26 and 32; Figs 8, 9) and 34 are of flowering plants, mostly herbaceous perennials (Figs 1, 10, 11). Nothing is known about the reasons, if any, for the choice of plants used for the Nature-Prints or whether they were chosen, collected and pressed by Bradbury or someone else, such as Lindley or Moore. There is no obvious taxonomic, pharmaceutical or ecological theme, although fifteen prints are of plants with "Common" in their English names and several are wetland species (Nos 2, 15, 19, 24, 32, 33, (36)). No.25 (*Asplenium marinum*) grows naturally only on walls and rocks close to the sea but most of the other plants would have been relatively easily available in the south of England, as garden plants or escapes if not as native plants. A few (No. (36), (38)) are found exclusively in the south of Britain. Most of the specimens must have been originally collected between early and late summer.

Although Wakeman (1966) says of the folio ferns: "one fern illustrated is the same as one which appeared in "*A few leaves.....*", all 5 fern species represented in Bradbury (1854) are also illustrated in Moore (1855/56). Perhaps it was the success with these specimens published in 1854 that prompted the decision to illustrate Moore's fern book. However, different specimens and plates were used for all five species and two were renamed in the later work. *Lastrea spinosa* New. (No. 15, Fig.8) in Bradbury (1854) became *L. spinulosa* Presl. (now = *Dryopteris carthusiana*), with no mention of the name 'Withering's Fern', in Moore (1855/56). *L. recurva* New. (No. 20) in Bradbury (1854) was changed to *L. foenisecii* Watson (now =*D. aemula*), with no

mention of 'Bree's Fern' in the later work.

Some of the minor differences between some plate names as given in the RI list and the corresponding name engraved on the plates (see Table 1) indicate that the engraver was working from a hand-written list of names that were unfamiliar to him.

SUMMARY

Henry Bradbury produced at least 6 fern Nature-Prints before Moore (1855/56). His unpublished 'Phytoglyphs', including one of *Polystichum aculeatum* in the Wellcome Library, may be earlier than his first published Nature-Prints of ferns in "*A few leaves*...." This publication has no text, but there is a printed list of plates and a title page with the date '1854'. The prints were certainly produced before February 1855, when an unbound set of 5 prints of ferns and 28 of flowering plants was donated by him to the Royal Institution. A similar set of 33 plates, with the same title page and list of plates, was acquired by each of the British Museum (now British Library), Bodleian Library, Oxford, and Cambridge University Library, probably as Copyright Act deposits. Another set of 33, with a different title page and at one time privately owned but now at Cambridge University Library, contains some additional plates of flowering plants. All these sets were bound after they had been acquired. According to an

Figure 8. Bradbury (1854), Plate 15: '*Lastrea spinosa*, Withering's Fern' (= *Dryopteris carthusiana*).

Figure 9. Bradbury (1854), Plate 26: '*Scolopendrium vulgare*, Common Hart's Tongue' (=*Phyllitis scolopendrium*).

announcement on the title page, unbound plates were also sold singly and in sets of 21 selected plates. Three 21-print sets, with different selections of plates but all including some ferns, and an incomplete set of 3 prints have been traced. Only one of these sets has a title page, and only one is bound. An unbound set can be seen at the Victoria & Albert Museum. Taken together, these sets reveal that at least 39 different plates were produced. These prints are notable for including the only Nature-Prints of flowering plants published by Bradbury. Five prints are of ferns. The prints were later re-issued, after plate numbers had been engraved on the original plates, probably in sets of 14 selected from the full list. Two of these 14-print sets, without title pages and unbound, are currently known; neither includes any fern prints. One of these sets is in the Wellcome Library and can be viewed on their web-site. The Wellcome records indicate that these numbered prints in sets of 14 were issued by Baildon in Edinburgh, c.1867. The source of this information has not been traced, nor is it known whether these sets were printed in London by Bradbury & Evans nine years after the premature death of Henry Bradbury, or in Edinburgh using the same plates and similar paper.

Figure 10. Bradbury (1854), Plate 5: '*Alchemilla vulgaris*, Common Lady's Mantle'.

Figure 11. Bradbury (1854), Plate 35: '*Primula vulgaris*, Common Primrose'.

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I am grateful to Caroline Marten for her considerable help in locating and examining copies of Bradbury (1854).

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TABLE 1. The prints represented in the 11 known sets of Bradbury (1854)
"+" indicates a print present in the set(s) identified by an abbreviation in the top row of the column; sets are described in full in the text.
Abbreviations as follows: RI (Royal Institution Library, London); BL (British Library); BLO (Bodleian Library, Oxford); CUL1 (Cambridge University Library, Reference Number: MH.7.8); CUL2 (Cambridge University Library, Reference Number: CCF.47.19); PUNCH (Punch Cartoon Library and Archive, London); CUL3 (Cambridge University Library, Reference Number: Waddleton.bb.9.1.38); V&A (Victoria and Albert Museum Print Library, London); AFD (privately owned, A F Dyer);WL (Welcome Library, London); MF (privately owned in New Zealand).
Numbers in the WL and MF columns are the Plate Numbers engraved on the plate
Prints not on the RI list have been arbitrarily allotted Nos (34) to (39).

RI List Numbers 1-33, plus extra prints (34) - (39)	NAME OF PLATE Nos 1-33: name as given in RI list; the same text is on the plate, unless noted otherwise. Nos (34)-(39):name as on plate. (Differences in font size within each name are not reproduced below)	RI; BL; BLO; CUL1 33 prints	CUL2 21 prints	PUNCH 3 prints	CUL3 33 prints	V&A 21 prints	AFD 21 prints	WL 14 prints	MF 14 prints
1	UMBELLIFERAE, JUSS. (*Bupleurum rotundifolium, L.*) COMMON HARE'S EAR ('*Buphorum*' on plate)	+	+	+	+	+			
2	LABIATAE, JUSS. (*Mentha aquatica, L.*) WATER CAPITATE MINT	+	+	+		+	+		
3	PAPAVERACEAE, JUSS. (*Chelidonium majus, L.*) COMMON CELANDINE	+	+		+	+	+	+ 13	

4	RUBIACEAE, JUSS. (*Galium cruciatum, L.*) CROSSWORT BEDSTRAW	+			+			+ 1	*
5	ROSACEAE, JUSS. (*Alchemilla vulgaris, L.*) COMMON LADY'S MANTLE	+	+		+	+	+		
6	LABIATAE, JUSS. (*Stachys sylvatica, L.*) HEDGE WOUNDWORT	+	+		+	+	+		
7	HYPERICACEAE. (*Hypericum eloides, L.*) MARSH ST. JOHN'S WORT ('WART' on plate)	+	+		+	+	+	+ 8	+ 8
8	CAPRIFOLIACEAE, JUSS. (*Viburnum opulus, L.*) COMMON GUELDER ROSE	+						+ 9	
9	POLYGALACEAE, JUSS. (*Polygala vulgaris, L.*) COMMON MILKWORT	+			+	+		+ 14	
10	LEGUMINOSAE, JUSS. (*Orobus tuberosus, L.*) TUBEROUS BITTER VETCH	+	+		+	+	+	+ 6	+ 6
11	CARYOPHYLLACEAE, JUSS. (*Arenaria trinervis, L.*) THREE-NERVED SANDWORT	+	+		+	+	+	+ 2	+ 2
12	COMPOSITAE, JUSS. (*Gnaphalium uliginosum, L.*) MARSH CUDWEED ('*Guaphalium*' on plate)	+	+				+	+ 17	

13	PRIMULACEAE, VENT. (*Lysimachia nemorum, L.*) YELLOW PIMPERNEL	+	+	+	+		+		+ 26
14	TILIACEAE, JUSS. (*Tilia Europæa, L.*) COMMON LIME TREE	+	+		+	+			
15	FILICES. (*Lastrea spinosa, New.*) WITHERING FERN ('*new.*' and 'WITHERING'S' on plate	+	+		+		+		
16	LEGUMINOSAE, JUSS. (*Vicia sylvatica, L.*) WOOD VETCH	+			+			+ 11	+ 11
17	URTICACEAE, JUSS. (*Urtica dioica, L.*) GREAT NETTLE	+	+		+	+	+		
18	ROSACEAE, JUSS. (*Potentilla tormentilla, Sibth.*) TORMENTIL ('*Tormentilla*' on plate)	+			+				+ 3
19	PRIMULACEAE, VENT. (*Lysimachia vulgaris, L.*) GREAT YELLOW LOOSE-STRIFE ('LOOSE STRIFE' on plate)	+			+	+	+		+ 30
20	FILICES, LINN. (*Lastræa recurva, New.*) BREE'S FERN ('*Lastræe*' and '*Newn.*' on plate)	+	+		+	+			

21	GROSSULARIACEAE, DECAND. (*Ribes alpinum, L.*) MOUNTAIN CURRANT ('DE CAND' and '*Alpinum*' on plate)	+	+		+	+	+	+ 7	
22	EUPHORBIACEAE, JUSS. (*Mercurialis perennis, L.*) DOG'S MERCURY	+	+				+	+ 23	
23	COMPOSITAE, JUSS. (*Filago Germanica L.*) COMMON FILAGO	+	+		+		+		+ 21
24	ROSACEAE, JUSS. (*Spiraea ulmaria, L.*) MEADOW SWEET ('*Ulmaria*' on plate)	+						+ 10	+ **
25	FILICES. (*Asplenium marinum, L.*) SEA SPLEENWORT	+	+		+	+			
26	FILICES, LINN. (*Scolopendrium vulgare, Sym.*) COMMON HART'S TONGUE	+			+	+			
27	ONAGRACEAE, JUSS. (*Epilobium angustifolium, L.*) ROSE-BAY WILLOW-HERB	+	+		+		+		
28	LILIACEAE, JUSS. (*Convallaria majalis, L.*) LILY OF THE VALLEY	+			+				
29	COMPOSITAE, JUSS. (*Serratula tinctoria, L.*) COMMON SAW-WORT	+	+		+			+ 22	

30	COMPOSITAE, JUSS. (*Solidago virgaurea, L.*) COMMON GOLDEN-ROD ('*Virgaurea*' on plate)	+			+	+	+		
31	COMPOSITAE. (*Petasites vulgaris, Desf.*) COMMON BUTTER-BUR	+	+		+	+	+		+ 24
32	FILICES, LINN. (*Osmunda regalis, L.*) FLOWERING FERN ('*Osmund*' on plate)	+			+	+	+		
33	RANUNCULACEAE, JUSS. (*Caltha palustris, L.*) COMMON MARSH MARYGOLD	+			+		+		
(34) NOT ON RI LIST	CRUCIFERAE (*Arabis hirsuta, Por.*) HAIRY ROCK-CRESS					+			+ 16
(35) NOT ON RI LIST	PRIMULACEAE, VENT. (*Primula vulgaris, Huds.*) COMMON PRIMROSE				+	+	+		
(36) NOT ON RI LIST	RANUNCULACEAE, JUSS. (*Thalictrum flavum, L.*) COMMON MEADOW RUE				+				+ 15
(37) NOT ON RI LIST	RUBIACEAE, JUSS. (*Galium erectum, Huds.*) UPRIGHT BED-STRAW				+			+ 12	+? 12*
(38) NOT ON RI LIST	CUCURBITACEAE, JUSS. (*Bryonia dioica, Jacq.*) RED BERRIED BRYONY				+				+ 31

(39) NOT ON RI LIST	SOLANACEAE, JUSS. (*Solanum nigrum, L.*) COMMON NIGHTSHADE				+				
Title page present (Type 1 or Type 2)		YES (1)	NO	NO	YES (2)	YES (2)	NO	NO	NO
'Opinions of the press' present		YES	NO	NO	NO	NO	NO	NO	NO
'List of plates' present		YES	NO	NO	NO	NO	NO	NO	NO
Plates numbered (plate numbers shown in appropriate squares under WL and MF):		NO	NO	NO	NO	NO	NO	YES	YES
Plates in contemporary binding (cb), modern binding (mb), or unbound (ub):		RI: mb; BLO: cb; BL: cb; CUL1:cb	ub	ub	cb	ub	cb	ub	ub

* The owner of MF reports that the set contains "Galium cruciatum, Plate No. 12". Assuming "Plate No. 12" is correct, the print is of Galium erectum (No (37) above).

** The owner of MF reports that the set contains the plate of Spiraea ulmaria but gives the Plate No. as "?", probably because the corner of the print has broken off.

BOOK REVIEW

A NATURAL HISTORY OF FERNS. Robbin Moran. 2004. Hardback with dust cover. 301pp., 144 figures (line drawings and photographs), 26 pls (colour).
ISBN 0-88192-667-1. Timber Press. £22.50.

There are various ways of writing reviews, just as there are many ways of writing books on ferns. Some books can be catalogues, listing families, genera and species, useful for taxonomists or plant geographers, but of only a passing interest to many pteridologists and their reviews cannot be much else than praising or disputing the taxonomy. Others books may be scientific compilations of facts aimed at students at one level or another and the reviewer tries to asses their value in teaching curricular. Horticultural fern books are something else again and the reviewer is pleased to find good ones not that only instruct on how to grow ferns but ones that inspire the reader to get out there and do it. Occasionally there are more general fern books that are interesting to read and a pleasure to review.

Once I reviewed what I described as the worst book on ferns I had ever read. It was not only full of mistakes, but it was boring as well. Now it gives the greatest pleasure to review one of the best books on ferns that I have ever read – not skimmed, not dipped into, but read. Robbin Moran writes in such an easy and interesting style taking the reader from observations and personal reminiscences into facts and back again with such ease that science becomes part of the story and the story becomes part of the scientific understanding. Enthusiasm comes through from the author's wide knowledge of the subject, something which dragged me inexorably onward to the end of the particular story that was unfolding on the pages.

It is not a text book, nor a field guide, but an exploration of the biology of ferns, with side excursions into lycophytes and horsetails, their life in the wild, their fossil history, and how they affect our lives. The book is written as a series of essays that follow on from each other in a logical sequence to introduce the reader to a full range of fern facts. Broken down into sections on The Life Cycle of Ferns, Classification, Fern Fossils, Adaptations by Ferns, Fern Geography, and Ferns and People, Robbin Moran manages to bring the subject alive in a series of chapters that intermingle facts with information about the people who discovered them, personal observations and the odd quote here and there from historic books and poets. When was the last time you read an interesting science book that started with a quote from Shakespeare? The use of a quote from Henry IV gripped my attention from the very start; an inspired beginning that promised much, and delivered, as the story progressed. If you don't know why it was from this particular play you should read the book to find out.

Anyone who reads the Fiddlehead Forum of the American Fern Society will find many of the chapters familiar, but Robbin Moran has revised, enlarged and updated them, then aligned them with new chapters in order to weave his personal voyage through the natural history of ferns. There are monochrome and colour photographs and line drawings that augment the written information, a useful glossary, some key references and an index.

I can do no better than quote Oliver Sachs from his foreword to the book "A Natural History of Ferns not only represents science writing at its best, but is a delightful adventure into the world of one of our foremost botanists; it is stimulating, enthralling, a beautiful companion for any fern lover." My only other thought is to wonder why it is not in paperback and in the popular science section of airport bookshops; it's as good as the best you can find there. So, I leave you with two words – buy it.

Barry A. Thomas.

DISCOVERY OF THE GAMETOPHYTES OF *TRICHOMANES SPECIOSUM* (HYMENOPHYLLACEAE: PTERIDOPHYTA) IN POLAND AND ITS BIOGEOGRAPHICAL IMPORTANCE

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Key words: *Trichomanes speciosum*, gametophyte, ecology, biogeography, Poland, Central Europe

ABSTRACT

Gametophytes of *Trichomanes speciosum* Willd. (Hymenophyllaceae: Pteridophyta) have been reported for the first time in two localities in the Westsudetian Highland, Lower Silesia, SW Poland. They form the easternmost outposts of this taxon in Europe, suffering the most severe climatic conditions in the extent of its occurrence. At both sites gametophytes occur in horizontal rock fissures in Upper Cretaceous sandstone, surrounded by degraded eastern oak-hornbeam forests. The gametophytes are very small (up to 2 cm diameter) and sparse.

INTRODUCTION

The Killarney Fern *Trichomanes speciosum* Willd. (syn. *Vandenboschia speciosa* (Willd.) G.Kunkel) is the only European representative of a predominantly tropical genus. It is a Macaronesian-European endemic (Rumsey *et al.* 1998b), classified as an extremely oceanic *Hymenophyllum wilsonii*-element of pteridophyte flora (Birks 1976). The restriction of *Trichomanes speciosum* sporophyte to areas of hyperoceanic climate, coupled with its historical excessive collection, resulted in legal protection throughout the species range under the Bern Convention (Anon. 1979) and Habitat Directive (Anon. 1992). Sporophytes and gametophytes of *Trichomanes speciosum* are perennial and both phases of its life cycle are capable of vegetative propagation, with extensive clonal development of either generation. They have often existed as spatially separated populations (Farrar 1985), where sporophytes are restricted to the European Atlantic fringe (Jalas & Suominen 1988) and gametophyte distribution extends over the more continental part of Central Europe (e.g. Vogel *et al.* 1993, Rumsey *et al.* 1998b).

The bright green epilithic mats of *Trichomanes speciosum* gametophytes at first glance resemble the protonema of bryophytes or filamentous algae. The gametophyte prothalli consist entirely of highly branched filaments with numerous peripheral chloroplasts (Krippel 2001, Makgomol & Sheffield 2001). Recognition of the distinctive ecology and habitat of *Trichomanes speciosum* gametophytes resulted in independent discoveries in: Britain, France (northern Vosges), Luxembourg (Suisse Luxebourgeoise), Germany (Eifel, Spessart, Rhön, Oberpfälzer Wald, Elbsandsteingebirge) and the Czech Republic (České Švýcarsko, Labské pískovce, Kokořínsko, Český ráj, Parchovské skály) (e.g. Rumsey *et al.* 1990, Vogel *et al.* 1993, Rumsey *et al.* 1998a, Rumsey *et al.* 1998b, Krippel 2001, Turoňová 2002) (Fig. 1).

Gametophytes of *Trichomanes speciosum* Willd. have not been observed so far in

Poland but the nearest localities are situated in the close vicinity – in the area of Elbsandsteingebirge and České Švýcarsko, known also as Saxonian-Bohemian Switzerland. These localities are connected with the Lower Turonian sandstone massif dissected by the river Elbe with many deep gorges, whose geomorphology is a crucial ecological factor. These conditions are reflected by a relatively cooler and more humid microclimate in the ravines and determine the frequent presence of rare arctic-alpine, Atlantic bryophytes and vascular plants as well as *Trichomanes speciosum* gametophytes. The presence of scattered Cretaceous sandstones areas in the Sudetes foothills in Poland suggested the possible occurrence of *Trichomanes speciosum* there. The climatic conditions of this area differ from neighbouring Saxonian-Bohemian Switzerland massif in their greater continentality marked by lower mean air temperature – ca. +7 °C to +8 °C, and rainfall – ca. 650 mm to 720 mm respectively (Wiszniewski 1973, Vogel *et al.* 1993).

In early autumn of 2002 we made a reconnaissance of the potential localities of *Trichomanes speciosum* in the central and western part of the Sudetes foothills with the most pronounced oceanic climate features in comparison to the rest of the Sudetes sandstones. During September and October of 2002 we visited the potential localities in this area – both are isolated sandstone rocky formations and old quarries. In two localities we found *Trichomanes speciosum* gametophytes. The classification of plant communities follows Matuszkiewicz (2001). Plant distributions in 10-km grid squares for Poland (ATPOL) are presented accordingly to Zając (1978).

TRICHOMANES SPECIOSUM IN POLAND

In October 2002 we found two sites with only a few colonies of *Trichomanes speciosum* gametophytes in the West Sudetes foothills, Lower Silesia, SW Poland (Fig 1). The first of them, called 'Niedźwiedzia Jama' (Bear Pit), is located near Złotoryja (N51°06'20" E15°54'20"; ATPOL BE41). The gametophytes grew on the bare rock surface, free from competition under the overhang of a small cave at ca. 250m altitude on medium-grained sandstone of the lower Turonian. Walls of this cave were colonised by *Pseudotaxiphyllum elegans* (Brid.) Iwats. The cave was located in the upper part of a small valley that had a south-western aspect. The whole valley was covered by managed eastern oak-hornbeam forest (degraded form of *Galio sylvatici-Carpinetum betuli* Oberd. 1957) with very sparse undergrowth. The humus layer was thick and of moder type. The second location, called 'Panieńskie Skały' (Maiden Rocks), is 2 km south of Lwówek Śląski (N51°06'15" E15°35'30"; ATPOL AE49) at ca. 260m altitude. Three small patches up to 3 cm^2 of *Trichomanes speciosum* gametophytes were found low down, in ca. 50 cm deep south-facing crevices, in coarse-grained sandstone rocks of middle Cenomanian. In these crevices, gametophytes grew together with sparse mosses e.g. *Schistostega osmundacea* and *Distichum inclinatum* (Hedw.) B., S. & G. The sandstone ridge of up to 10 m high was surrounded by mixed forest with dense undergrowth. The herb layer was also sparse and impoverished as in the first locality. The thickness of humus layer and its type were similar too. Both Polish localities were ca. 20km away from each other and had similar climatic conditions with mean yearly temperature of +7.8°C, mean temperature January of -2.0°C and mean yearly rainfall of 660 mm (Wiszniewski 1973). The climate in this region is one of the mildest in Poland with pronounced oceanic features. The geomorphology of both localities does not foster temperature inversions.

REMARKS ON ECOLOGY

The narrow ecological amplitude of *Trichomanes speciosum* strongly limits the number

of its potential sites. The main factor determining plant distribution is a suitable microclimate with temperature and water supply the most important. The usual habitats of epilithic gametophytes of *Trichomanes speciosum* were deep cracks and small caves with limited light access. Consequently these habitats provide a moderately constant humidity and thermal regime, which prevent drying out or freezing of the delicate plant mats, resulting in desiccation of *Trichomanes speciosum* gametophytes (Farrar 1985). Growth rates noted by Raine & Sheffield (1997) corroborate thermal constraints of *Trichomanes speciosum* gametophytes' geographical distribution. Our observations suggest a wider ecological tolerance of *Trichomanes speciosum* gametophyte, which is adapted to an even more sub-continental climate. The new localities discovered in Poland are presently the easternmost outposts of *Trichomanes speciosum* gametophytes in Europe. Cretaceous sandstone massifs are also located further to the east, in Central Poland, but it seems that mezo- and microclimate conditions are too unfavourable there.

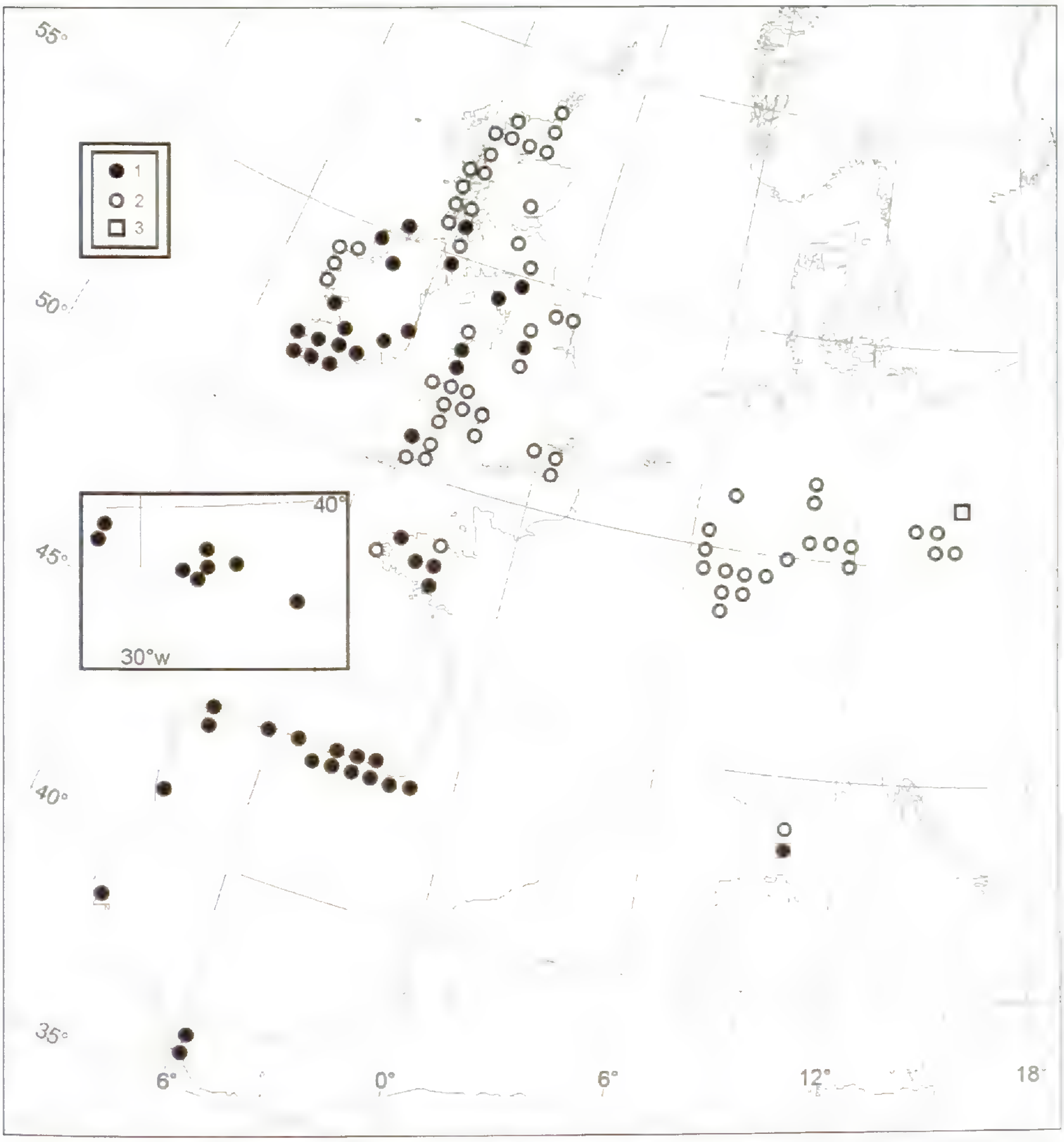

Figure 1. Distribution of *Trichomanes speciosum* mapped on the 50km UTM grid system. Both generations recorded (1- ●), gametophyte generation only (2- ⊙), new locality of gametophyte (3 - □). Macaronesian Islands in boxes. After Rumsey *et al.* (1998b) with some additions.

The subsequent ultimate factor is the adaptation of gametophytes to growing in extreme low light (PAR < 1 μmol m^{-2} s^{-1}) with low respiration rates and therefore a low compensation point, which enables it to survive free from competition from other species, especially shade tolerant bryophytes (Vogel *et al.* 1993, Makgomol & Sheffield 2001). It seems that in the peripheral outposts of *Trichomanes speciosum* gametophytes, very specific but stable microclimatic conditions on a small spatial scale are of high importance, especially high air humidity, which can be supported by a thick humus layer of moder type. Light limitation is not so stringent in lower temperatures (Raine & Sheffield 1997).

We should emphasise that a gradually narrowing substratum 'niche' of *Trichomanes speciosum* gametophyte is observed, from nearly calcareous man-made habitats in Macaronesia (Rumsey *et al.* 2000) or various substrates with some base enrichment in the British Isles (Ratcliffe *et al.* 1993) and Luxembourg (Vogel *et al.* 1993), to Cretaceous quartz sandstones in the north-eastern limit of its distribution area (Vogel *et al.* 1993, Turoňová 2002). The widespread distribution of Killarney Fern gametophytes might act as a kind of 'seed-bank' (Rumsey *et al.* 1999, Rumsey *et al.* 2000) producing very rarely observed sporophytes in favourable conditions (Rasbach *et al.* 1993, Ratcliffe *et al.* 1993). However the most important factor in the dispersal pattern of north-easternmost outposts of the *Trichomanes speciosum* gametophyte is its ability to disperse clonally by gemmae (Vogel *et al.* 1993), which was theoretically elucidated for asexual populations by Peck *et al.* (1998).

BIOGEOGRAPHICAL IMPORTANCE

The present distribution of *Trichomanes speciosum* gametophytes is the result of the ability to establish new colonies by the long distance dispersal of gemmae. They are produced quite frequently on gametophytes and are the only means of dispersal in the absence of sporophytes. Such situations suggest very low or even no genetic variability between populations or within sites. The distribution of multilocus phenotypes of *Trichomanes speciosum* gametophytes in Central Europe (Rumsey *et al.* 1998b) and at its northern limit in Scotland (Rumsey *et al.* 1999) was partitioned primarily between, not within sites, and argued against a purely 'stepping stone' or 'leading edge' type of colonisation. These data support the hypothesis of initial random colonisation of very few potential sites via long-distance spreading with secondary dispersal as gemmae, or limited opportunity for generation of new genotypes through sexual reproduction (Rumsey *et al.* 1998b). The last situation is possible due to sporophyte production that was reported amongst gametophyte mats in Vosges, France or Britain (Rasbach *et al.* 1993, Ratcliffe *et al.* 1993).

The historical and present distribution of *Hymenophyllum tunbrigense* (L.) J.E.Smith closely resembles the pattern of *Trichomanes speciosum*. Sporophytes of both species have very similar ecological requirements and occupy mainly shady, wet, non-calcareous rocks. They are known from a few 'relict' sites in continental Europe (Dostál 1984, Vogel *et al.* 1993). Former speculations regarding *Hymenophyllum tunbrigense* as a Tertiary relict in Luxembourg and Elbsandsteigebirge presented by Vogel *et al.* (1993) were partly supported by radiocarbon dates of tree charcoal in Belgium Ardennes and Western Slovakia (Stewart & Lister 2001). Both these localities are hypothetical temperate cryptic refugia during the Last Cold Stage at the end of the Pleistocene and could have provided a favourable microclimate for diverse vegetation in the sheltered habitats of deep gorges surrounded by peri-glacial tundra. Late Pleistocene and Holocene colonisation of *Trichomanes speciosum* from the main refugia in southern peninsulas (most probably Iberia) and Macaronesia, should also take

into account the facilitation of dispersal by prevailing south-western winds. Cryptic refugia in northern Europe such as in the Ardennes area could probably form hypothetical enclaves only for gametophytes of *Trichomanes speciosum*. Existence of such a refugium in Saxonian-Bohemian Switzerland appears less likely with regard to the proximity of the front of the Last Cold Stage glaciation, so colonisation of Elbsandsteigebirge by long-distance dispersal probably occurred no earlier than in the Atlantic hypsithermal (5000 - 3000 B.P.; Vogel *et al.* 1993). The Holocene migration has formed the present distribution range of *Trichomanes speciosum*, modified by adverse climatic fluctuations. The outposts of the *Trichomanes speciosum* in Central Europe could also reflect cold oscillations in the last Millennium, especially the Little Ice Age (540 - 100 B.P.) with a cooler and wetter climate in this area (Kociánová 2002), and form neo-refugia *sensu* Nekola (1999). Such conditions in Saxonian-Bohemian Switzerland massif were favourable for *Hymenophyllum tunbrigense* and perhaps for production of *Trichomanes speciosum* sporophytes too.

The effects of global warming, with slight signs of shifting to a warmer and wetter climate for the *Trichomanes speciosum* in Central Europe suggest more favourable conditions for completing its life cycle with the sporophyte phase. It reveals that implications for the conservation of an 'emblem' species of endangered European pteridophyte disagree with superficial public opinion focused only on celebrated sporophytes of *Trichomanes speciosum*. The Killarney Fern may be less threatened than it was feared (Moore 1998).

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We would like to express our sincere thanks to Johannes Ch. Vogel for enthusiastic inspiration of our field surveys and confirmation of collected specimens of *Trichomanes speciosum*. We are also deeply grateful to Yves Krippel and Dana Turoňová for guiding botanical excursions in Saxonian-Bohemian Switzerland, where we first realised the possibility of finding *Trichomanes speciosum* in Poland. We thank also Mrs Dorota Kazimierska for her help in preparing the figures and M. Sc. Sylwia Wierzcholska for determining the moss species.

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ON THE ECOLOGY AND DEMOGRAPHY OF A TERRESTRIAL POPULATION OF ASPLENIUM TRICHOMANES (ASPLENIACEAE: PTERIDOPHYTA) IN THE NETHERLANDS

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Key words: *Asplenium trichomanes*, Kuinderbos, demographic data, ecology

ABSTRACT

In the 19th century and the first half of the 20th century, terrestrial growth of *Asplenium trichomanes* L. was mostly confined to the southern part of Limburg. Today terrestrial growth is almost confined to the Kuinderbos, a planted wood in one of the reclaimed polders of the former Zuiderzee. The first plants established 20 - 25 years after tree planting. The preference for *Picea sitchensis* stands and a northeast exposure has not changed over 25 years. Two subpopulations have been monitored since 1988/1991. One of these subpopulations decreased in size due to overgrowth by herbs and *Rubus* spp., the other subpopulation increased after repeated thinning of the tree stand. The fern plants appeared to be fertile at an age of three to seven years. Mortality was highest in the juvenile phase. On average, plants died at six years old, though the oldest plant is more than 25 years old. Careful management of the *Picea sitchensis* stands is advised because with too much incoming light *A. trichomanes* plants will be out-competed by other species of the herb layer. Results of long-term monitoring of three populations (Utrecht, Amsterdam and Kuinderbos) were analysed. A negative effect of severe winters was evident.

INTRODUCTION

In The Netherlands *A. trichomanes* subsp. *quadrivalens* D.E. Mey. is primarily a wall dwelling species. In the nineteenth and first half of the twentieth century, plants growing in soil were found in the southern part of the Netherlands, where calcareous soils are exposed at incursions (Weevers et al., 1948). Material was collected here for the first time in 1887. At the beginning of the last century the species was not rare in this habitat but subsequently it disappeared and after 1950 no terrestrial plants were found. From 1977 soil dwelling plants have been recorded from the Kuinderbos. Some were found in the Revebos (also in the province of Flevoland) and in the Dutch dune area (Buiten, 2001).

In the Kuinderbos *A. trichomanes* was only one of the numerous rare fern species which colonised this planted woodland on a former sea bottom in the 1960s and 1970s. In 1979 all sites were ecologically described (Bremer, 1980). At the same time, monitoring was started in order to gain insight into temporal factors affecting this species. This paper is focused firstly on the question as to how far the species has changed its ecological niche at the Kuinderbos during 25 years, and secondly on the demography of the species and its relation with the woodland management.

The Area

The Kuinderbos is one of the woodlands planted after the reclamation of the Noordoostpolder. Half of the area (c. 1100 ha) consisted in 1980 of stands of *Picea abies* (L.) Karst. and *Picea sitchensis* (Bong.) Carr., sometimes intermingled with *Quercus robur* L.. There is a lot of variation in soil composition: deposits of acidified heavy clay, calcareous fine grained sand on peat (peat erosion area), moderately-grained sand and Pleistocene sand. The peaty area has been drained by trenches up to 0.7 km/ha, with a total length of 240 km. Their depth ranges from 0.4 - 1.5 m and are usually positioned from northwest to southeast. The phreatic level is usually below the bottom of these trenches. On trench banks, the fine-grained calcareous sand is exposed. Thinning of the woodland takes place once per five to eight years. In the area 28 fern species were found, of which 10 species are in the Red List of threatened species (Bremer, 1980 a, b). *Asplenium viride* Huds. and *Polystichum lonchitis* (L.) Roth. were recorded here for the first time in the Netherlands (Bremer, 1981), while *Polystichum setiferum* (Forssk.) Woynar was rediscovered here. Most of the rare species are calcicole and linked with the calcareous fine sand exposed at the trench banks.

MATERIALS AND METHODS

In the period 1978 - 1988 most sites with *Asplenium trichomanes* were visited annually, plants mapped and the number of plants counted. From 1988 and 1991 all plants from high density sites were mapped more accurately and recognised by labels beneath the plants. On a yearly basis these plants were visited at the end of August or the beginning of September. The number of fronds per plant (n), the fertility and the maximum size of fronds per plant (Lmax) were measured annually in the two plots (2 and 3 m^2 in size). In spring the survival after severe winters was checked. Longevity has been calculated on the basis of following individual plants from their establishment as sporelings. The demographic data have been worked out by using projection matrices (Caswell, 1989). The demographic data of various years have been pooled to construct one matrix due to the low number of plants per year.

In this study the severity of the winters is summarised in the index of IJnsen as follows: IJ = (v/3632) x (y/310) x (z/9), where v is the number of days with frost (minimum day temperature below 0°C), y the number of 'icy days' (maximum day temperature below 0°C) and z the number of 'very cold days' (maximum day temperature below -10°C) (IJnsen, 1991). Winters with IJ > 25 are considered severe. Temperature data were obtained from the Royal Dutch Meteorological Institute (KNMI).

Ecology

A number of ecological aspects could be compared for three periods: 1977 - 1982, 1983 - 1992 and 1993 - 2002. All plants were strictly linked with trench banks, where they were rooting in the fine grained calcareous sand. At one location, plants were rooting in a more coarsely grained sandy soil, mixed with calcareous fine sand. In the first period, plants grew on steeper trench banks (69.2° ± 10.9°, n = 13) than in the third period (54.0° ± 20.0°, n = 54)(t-test, df = 34, p < 0,001) (Table 1). When comparing the sites no difference in aspect could be assessed. There was a significant preference for a northeast aspect during two out of three periods when considering individual plants.

When considering the sites there was no significant preference for a stand type, but considering the plants, most of them were significantly more likely to be growing under

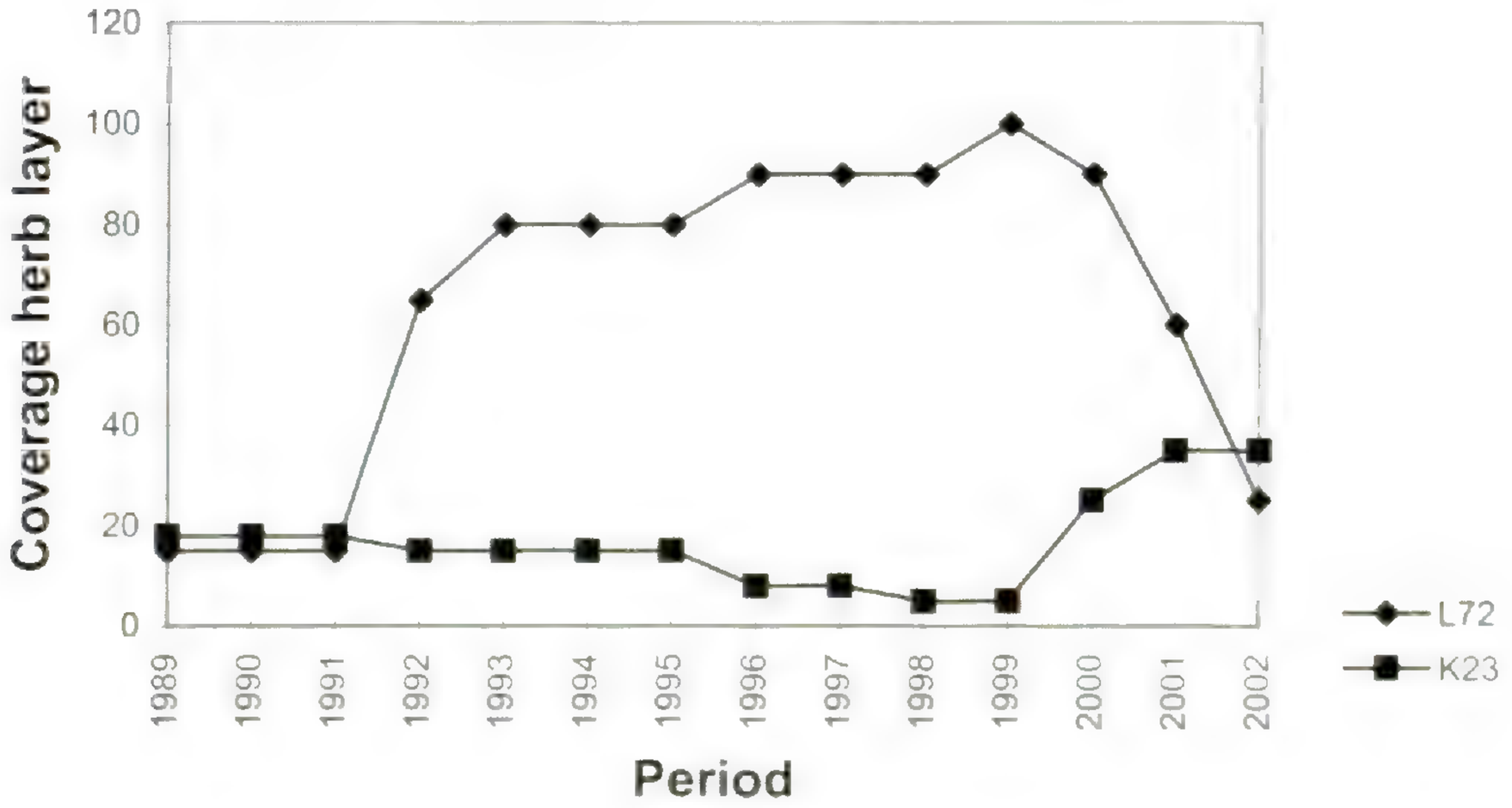


Figure 1. Coverage of the herb layer in both subpopulations.

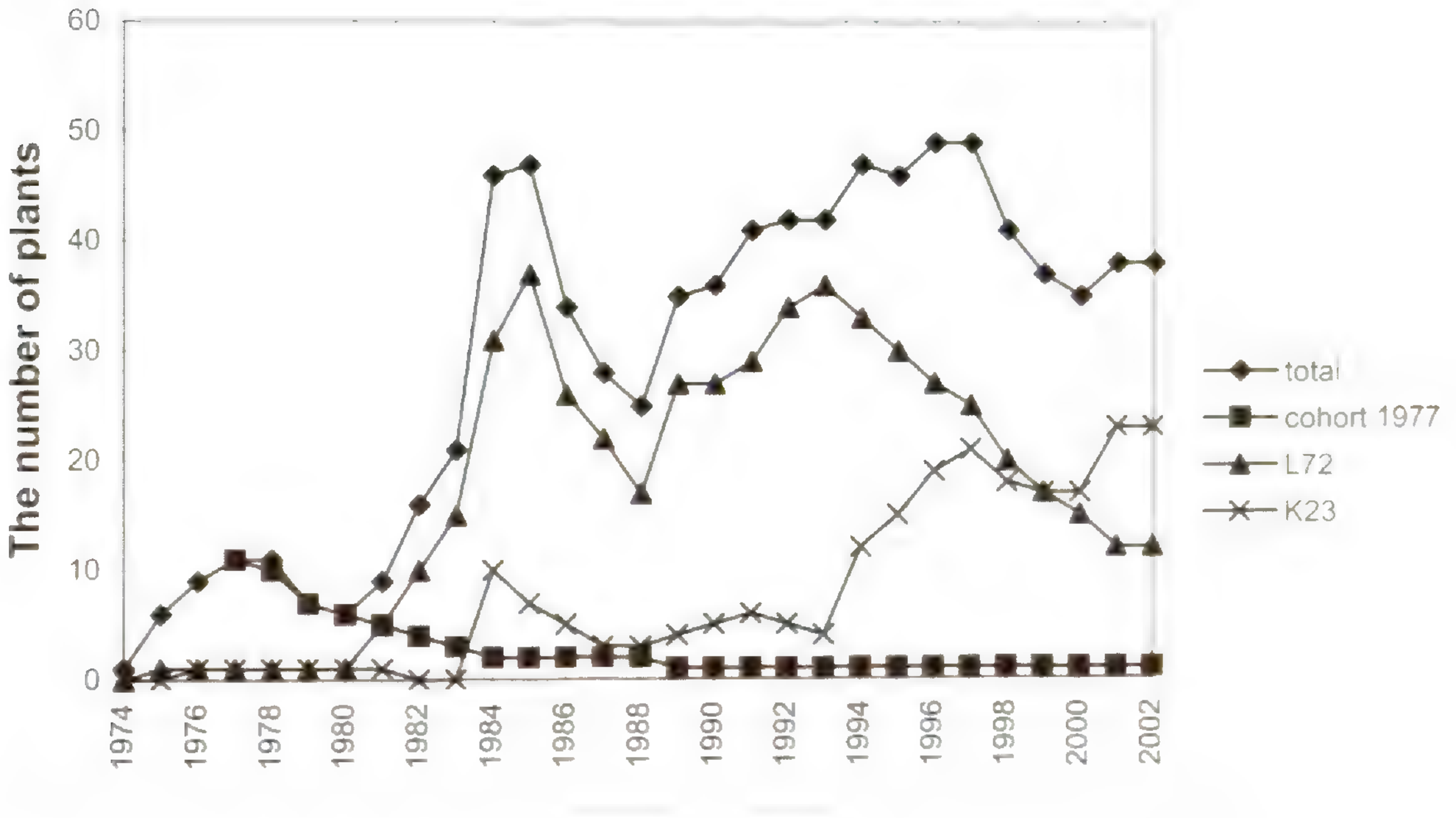


Figure 2. The number of specimens of *Asplenium trichomanes* for both subpopulations and the 1977 cohort in the Kuinderbos over a 30 year period.

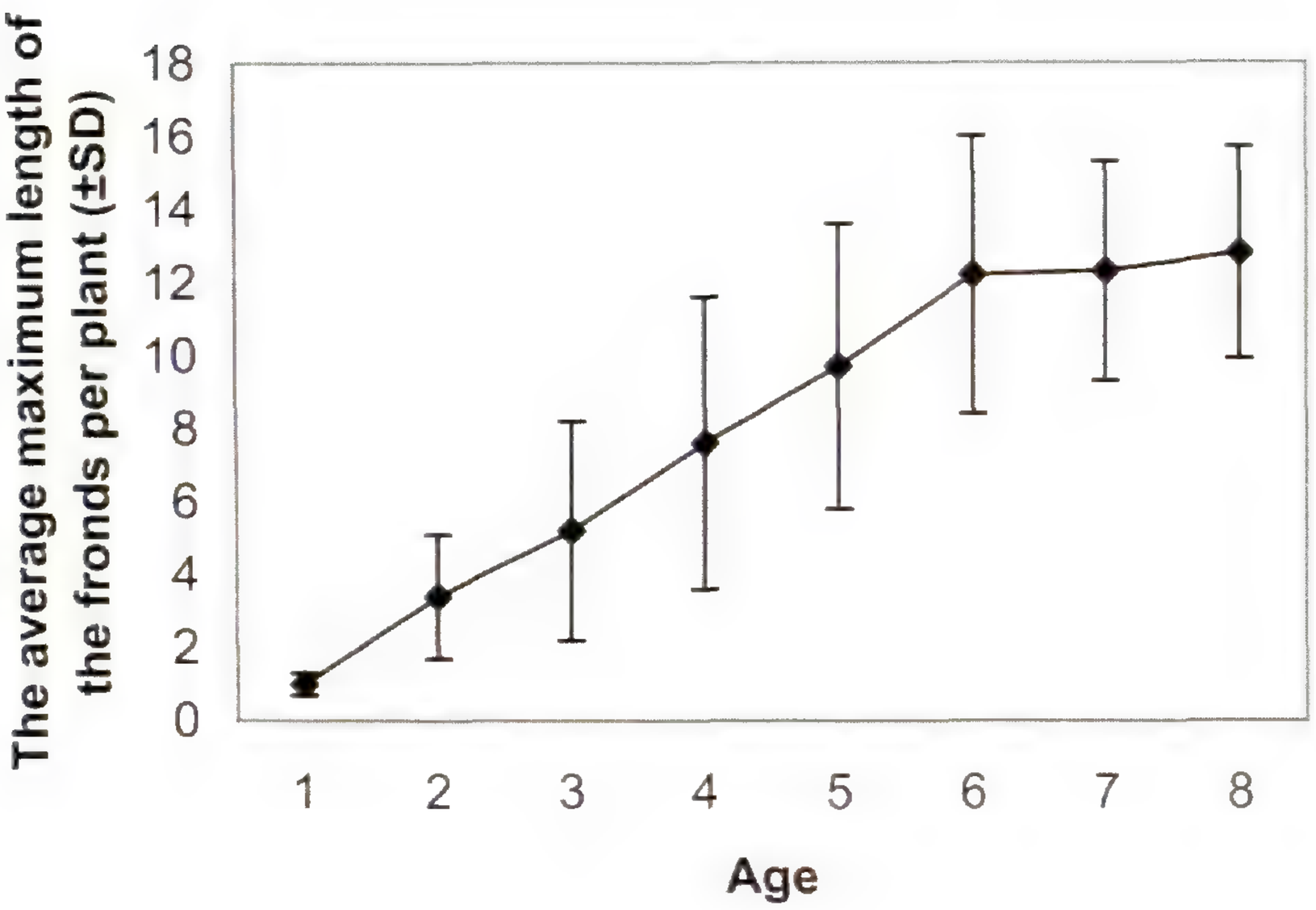


Figure 3. The relationship between age and the average maximum length of the fronds per plant, based on data from both subpopulations.
SD = standard deviation.

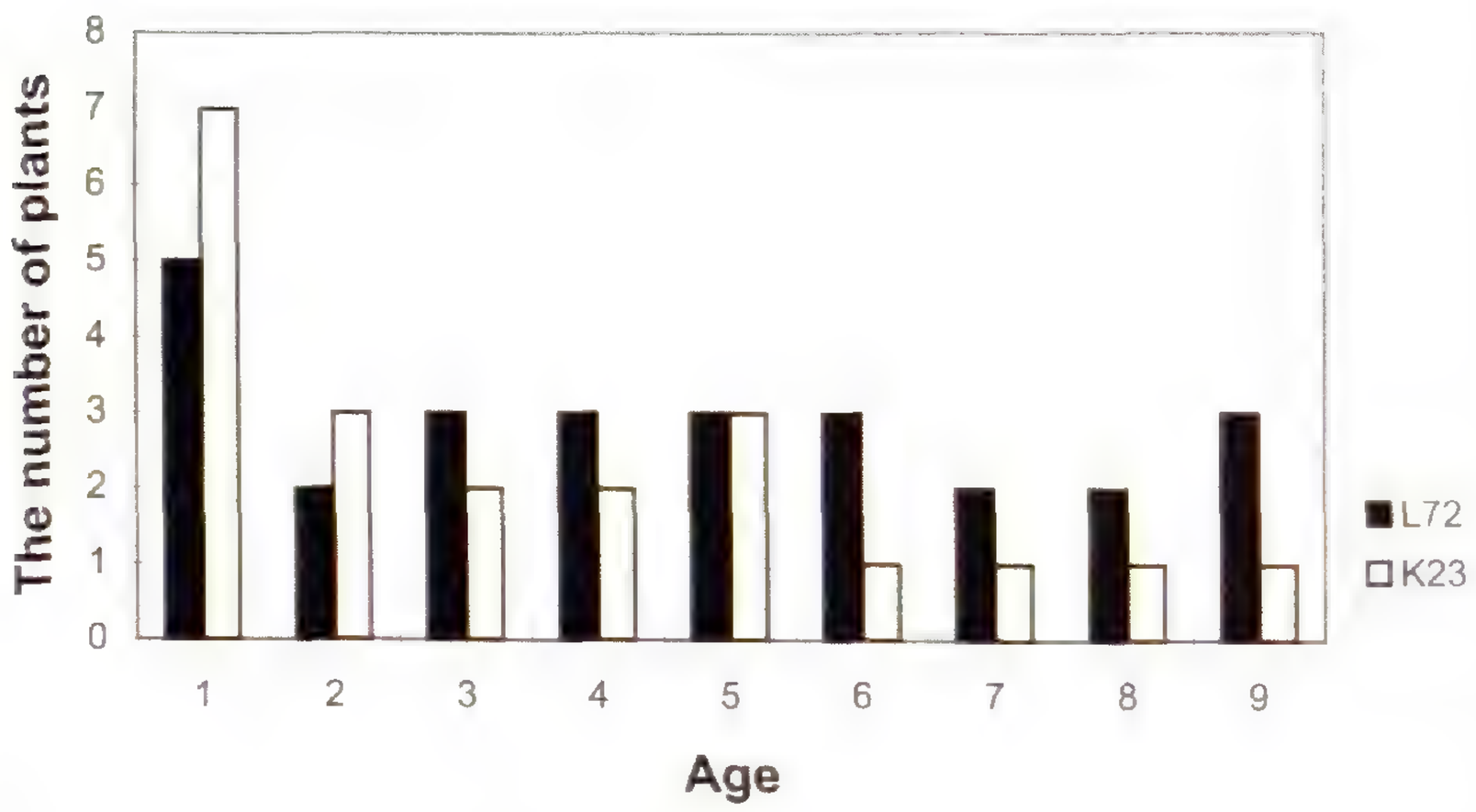


Figure 4. Longevity of *Asplenium trichomanes* in two subpopulations in the Kuinderbos.

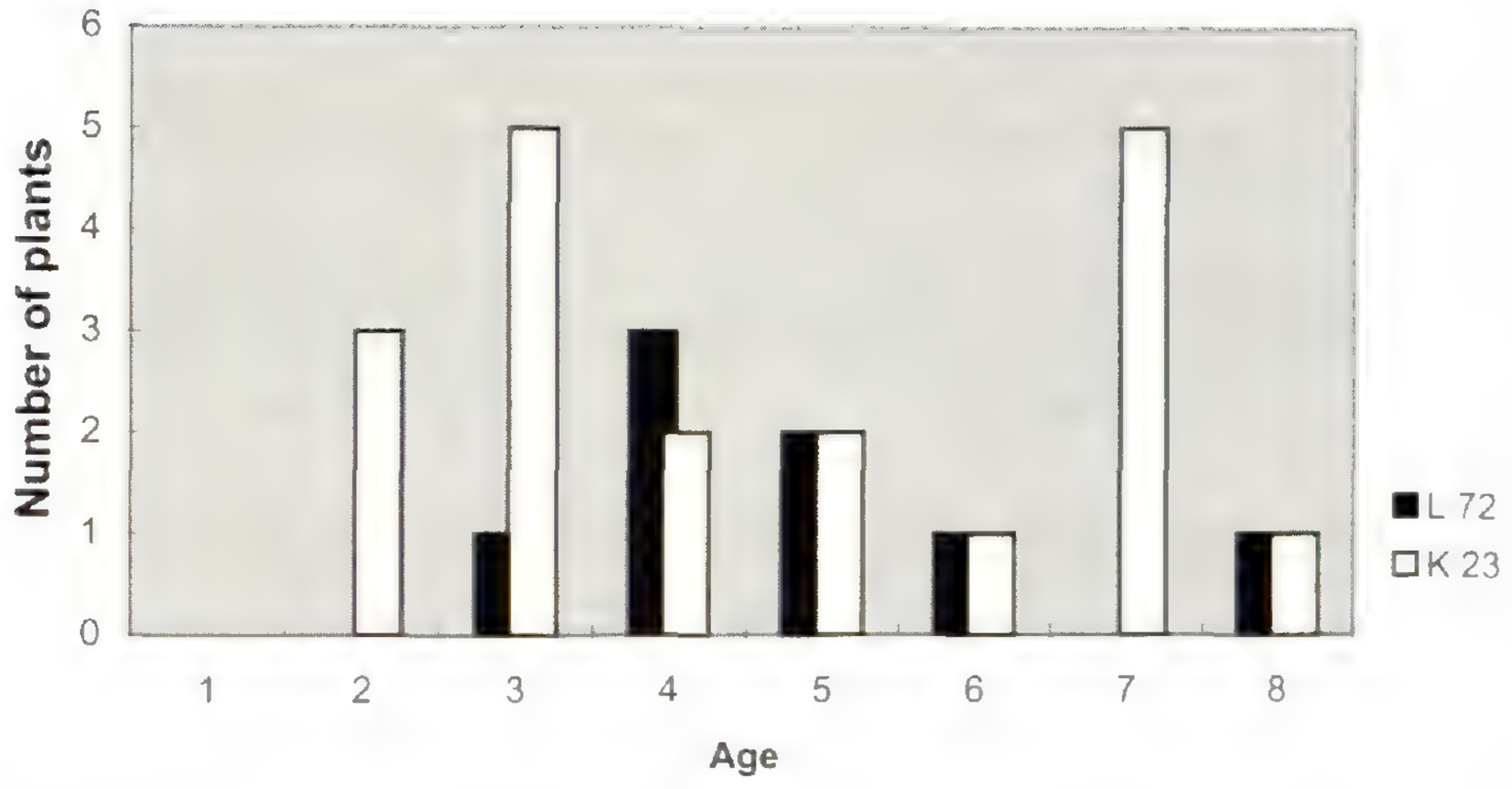


Figure 5. The age of plants in the transition from subadult to adult plant for both subpopulations in the Kuinderbos.

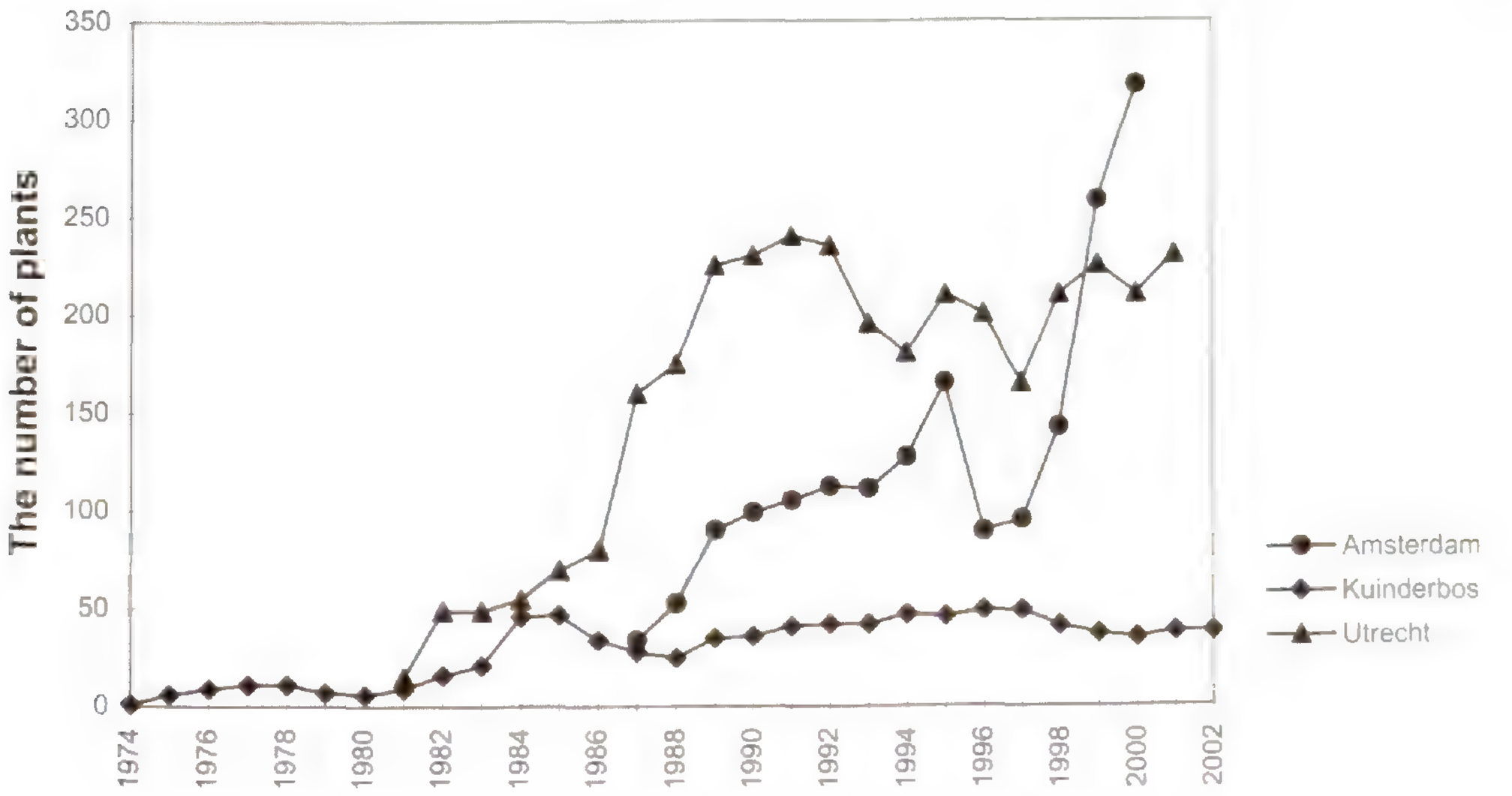
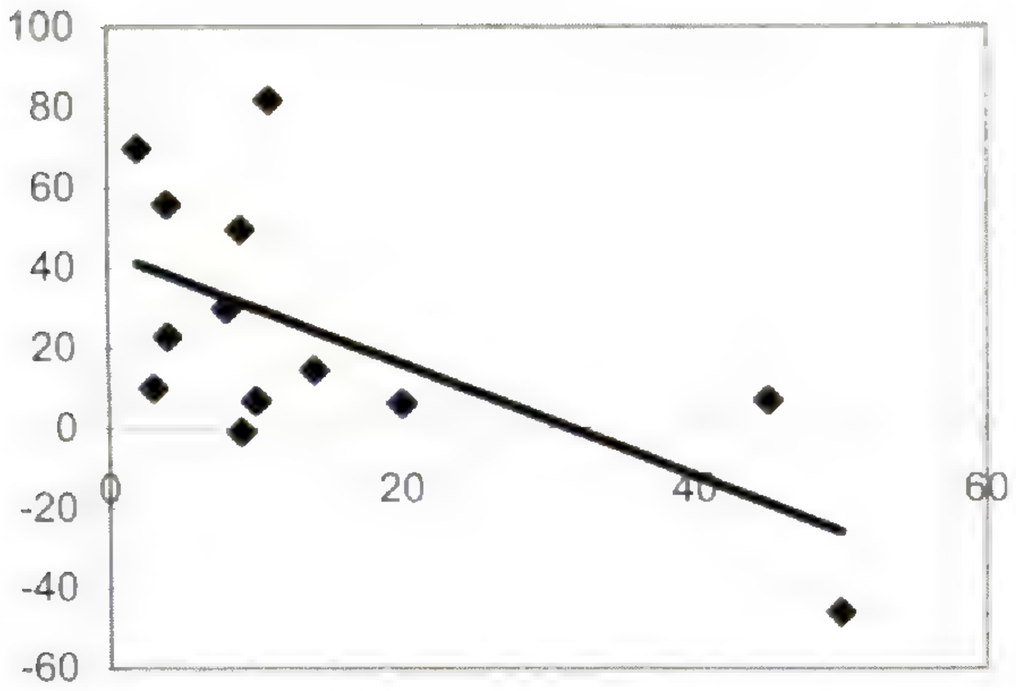
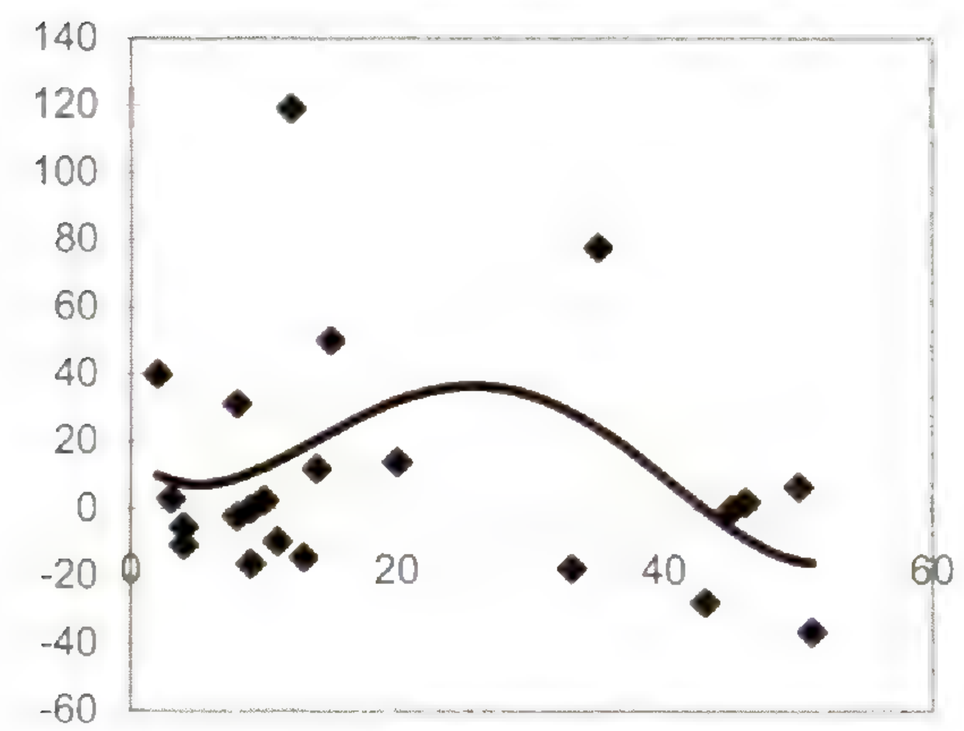


Figure 6. Number of specimens in three Dutch populations (based on Maes & Bakker. 2002).





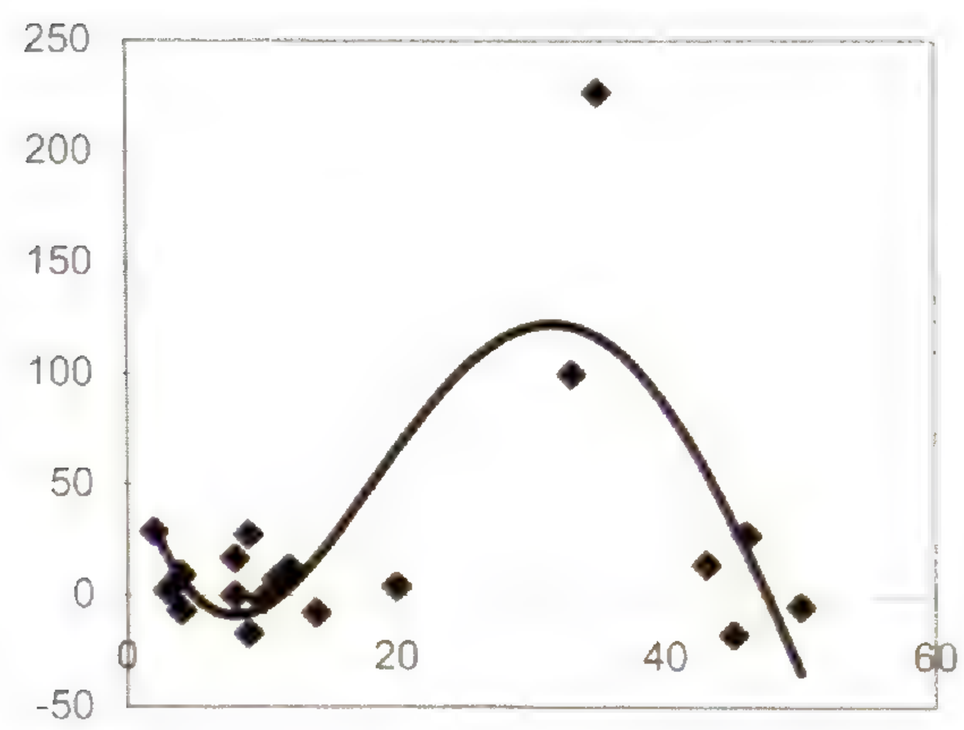


Figure 7. Relationship between the number of 'ice' days (parameter of IJnsen) and the change in population size [(no .in year t no. in year t-1)/(no. in year t-1) * 100%] for the three Dutch populations: A: Amsterdam (linear function, significant), B: Kuinderbos (quadratic function, significant), C. Utrecht (quadratic function. significant).

Picea sitchensis. At one site plants often grew at the edge of *P. sitchenensis* and *Fagus sylvatica* avenues, but there was no significant preference (n = 12, X^2 = 3.49 n.s.). During the first period *A. trichomanes* was growing in dense single cohort stands. In 1979 the cover of the herb layer was between 5 - 50 % (on average 18 %, n = 10). Specimens were growing with other fern species such as *Dryopteris filix-mas* (L.) Schott), *D. dilatata* (Hoffm.) A.Gray, *D. carthusiana* (Vill.)H.P.Fuchs, *Athyrium filix-femina* (L.) Roth., *Gymnocarpium dryopteris* (L.) Newm. and *Asplenium scolopendrium* L. During the third period most plants were concentrated in the two monitored plots. At one plot (designated as L 72) *Dryopteris dilatata, D. filix-mas* and *Athyrium filix-femina* were the accompanying species. Brambles (*Rubus flexuosus, R. idaeus*) were able to increase after gap formation in 1990 (Figure 1). *Circaea lutetiana* also invaded the plot and contributed considerably to the coverage. At the other site (designated K 23) *Asplenium trichomanes* has been accompanied only by *Dryopteris dilatata, D. filix-mas, Athyrium filix-femina, Gymnocarpium dryopteris* and *Asplenium scolopendrium*. At this site there was less incoming light (< 5 %) (Fig. 1).

Demography

Number of plants

During the first inventory of the Kuinderbos in 1979, 11 adult plants were recorded at various locations. Only one plant of this cohort survived for more than 25 years. There was a decline in population size in the period 1977-1981 (Fig. 2). During the severe winter of 1978 79 sites with *A. trichomanes* eroded and plants ended up at the bottom of the trenches and drowned in a 10 - 20 cm depth of water. In the period 1981 - 1984 recruitment took place around one adult plant forming a small subpopulation. This subpopulation (L 72) decreased in the second half of the 1980s. After 1988, recovery took place, producing an increase in population size until 1993, followed by a constant decrease. A second subpopulation (K 23) came into being by the same process, recruitment in the spore shadow of an adult plant. In this subpopulation the number of plants increased gradually after 1994. Together the two subpopulations account for more than 90 % of the whole Kuinderbos population.

The relation between maximum length of frond per plant (Lmax) and age has been worked out in order to reconstruct the colonisation of the Kuinderbos by *A. trichomanes*. We found that Lmax saturates after six years of growth (Fig. 3). Based on the curve and yearly measuring of Lmax the first establishment in the area took place

TABLE 1. The preference for stands of *Picea sitchensis* and exposure for three periods in the Kuinderbos.

			Tree layer % Sitka				Aspect					
Period	n loc	n ex	n loc	X^2	n ex	X^2	n loc		X^2	n ex		X^2
							NE	SW		NE	SW	
1973- 1982	16	23	43.7		78.3	***	7	5	-	17	5	-
1983-1992	12	56	50.0		92.8	***	5	2	-	46	3	***
1993-2002	5	83	40.0		96.8	***	3	5	-	78	5	***

n loc = number of locations, n ex = number of specimens. *** = $p < 0.01$.
NE = aspect to northeast, SW = aspect to southwest

in 1974 or even earlier. It cannot be excluded that the first plant had established by the end of the 1960s when in fact all the *Picea sitchensis* stands were in a dense stage. This means that the colonisation could have been started within 20 years of planting the woodland.

Changes in population structure

Within a population, various phases can be distinguished (Table 2). Sporelings have been defined on the basis of Lmax and age. Under certain circumstances this phase can be longer than one year. The difference between juvenile and sub-adult phase is based on Lmax. The number of fronds per plant also indicates a plant becoming larger, because the number of fronds per plant and Lmax are strongly correlated ($n = 235$, $r = 0.67$ $p < 0.001$). However, only Lmax is used for the classification. Plants were designated as adult plants when they had sori able to produce spores. Post-adults comprise adult plants which became sterile. Table 3 summarises the changes for the phases of both subpopulations (period 1993 - 2002).

In the L 72 subpopulation 190 transitions were assessed in a period of 10 years. Table 3 indicates transitions between various phases. Most important is the transition of adult plants remaining adult (65 % of all transitions). There is a limited rejuvenation in this population. Six percent of the transitions comprise the transition from adult to post adult, indicating less vitality. λ (lambda) has been calculated as 0.9, also indicating a

TABLE 2. The definition of the phases used in the study on *Asplenium trichomanes*.

Phases	**L max (cm)**	**Remarks**
Sporelings	<1.5	Usually less than one year old
Juvenile plants	1.5 - 4	
Subadult plants	> 4	
Adult plants	-	at least one frond with ripe sori
Post adult plants	-	plant was previously fertile

Lmax = maximum frond length per plant.

TABLE 3. The projection matrices with transitions summarising the observations made during 9-10 years.

		Year t				
		s	**j**	**sa**	**a**	**pa**
Year	**s**	3	0	0	0	0
t + 1	**j**	25	11	0	0	0
	sa	3	8	12	0	0
	a	2	6	7	51	0
	pa	0	0	0	0	0
	mortality	8	3	4	6	0
	total	41	28	23	57	0

K 23: numbers 1988-2001

		Year t				
		s	**j**	**sa**	**a**	**pa**
Year	**s**	0.07	0	0	0.59	0
t + 1	**j**	0.61	0.39	0	0	0
	sa	0.07	0.29	0.52	0	0
	a	0.05	0.21	0.3	0.89	0
	pa	0	0	0	0	0
	mortality	0.19	0.11	0.17	0.11	0
	total	1	1	1	1	0

K 23: transitions 1988-2001
$\lambda = 1.11$

		Year t				
		s	**j**	**sa**	**a**	**pa**
Year	**s**	0	0	0	0	0
t + 1	**j**	3	6	1	0	0
	sa	0	7	4	0	0
	a	0	0	7	119	5
	pa	0	0	0	15	11
	mortality	3	6	2	11	3
	total	6	19	14	145	19

L 72: numbers 1991 - 2001

		Year t				
		sp	**j**	**sa**	**a**	**pa**
Year	**s**	0	0	0	0.09	0
t + 1	**j**	0.5	0.32	0.07	0	0
	sa	0	0.37	0.29	0	0
	a	0	0	0.5	0.8	0.3
	pa	0	0	0	0.1	0.6
	mortality	0.5	0.32	0.14	0.1	0.2
	total	1	1	1	1	1

L 72: transitions 1991 - 2001
$\lambda = 0.91$

s = sporeling, j = juvenile, sa = subadult, a = adult, pa = postadult.
A projection matrix gives the changes from one demographic phase to another on a yearly basis. In this study the various years have been summed up in one matrix due to the low number of plants recorded per year.

decrease in population size (Caswell, 1989). In the K 23 subpopulation 162 transitions were assessed. Here the transition of adults remaining adults is less important (31 % of all transitions). There is a high proportion of the first three phases and transitions between them. No adult plants became post-adult plants. λ of 1.12 indicates a growing subpopulation.

Longevity

Longevity was calculated for those plants where the time of establishment was known (Fig. 4, n = 52). In the K 23 subpopulation, longevity was on average 3.7 years, in the L 72 subpopulation on average 5.3 years (whole population on average 4.8 years). Longevity per plant is skewed; many plants live for a short time, few plants become old. There was no significant difference between the two subpopulations ($X^2 = 4.99$, df = 10, $p > 0.05$).

Fertility

With a demographic investigation it is possible to calculate the time between the sporeling phase and a plant becoming fertile (adult). The adult phase is of importance because by producing spores a population can disperse. Plants can be fertile within two or three years, but for other plants this pre-fertile period can extend to eight years. On average plants are adult at an age of 4.7 years. There was no significant difference between the two subpopulations (Fig. 5) ($X^2 = 3.18$, df = 3, $p > 0.05$).

Other populations monitored

Monitoring of *A. trichomanes* has also taken place in the cities of Utrecht (1 subpopulation) and Amsterdam (11 subpopulations) by annual counting (Fig. 6) (Maes & Bakker, 2002). In these and other Dutch cities, *A. trichomanes* grows on walls beside canals. No individual monitoring has taken place. In Amsterdam more subpopulations were monitored, but these were excluded as population size was negatively influenced by wall cleaning or restoration.

In all populations there are significant (quadratic) correlations between the yearly change in number of plants and the severity of the winter. In both cities, but especially Amsterdam, there was a decrease after the severe winter of 1995/1996. The severity of the winter has been calculated with the parameter of IJnsen. Figure 7 indicates a negative correlation between population change and the parameter of IJnsen, with greater than 30 indicating the negative effect of severe winters. This effect is most notable in Amsterdam and the Kuinderbos.

DISCUSSION

A terrestrial population of *Asplenium trichomanes* colonised the Kuinderbos in the 1970s. Then the species was known only on walls and for a long time had not been recorded as rooting in the soil. In the first half of the twentieth century, terrestrial growth took place at incursions in the southern part of the Netherlands where marl soils are exposed but loamy soils predominate. The soils may have been acidified and as the incursions became more overgrown less erosion took place so that no marl came to the surface. But other unknown factors could have played a role as well.

As plants established in the Kuinderbos, stands of *Picea spp.* were in a dense phase and the herb layer suppressed. It seems most likely that the colonization started in the first half of the seventies. In 1972/1973 heavy storms damaged parts of the Kuinderbos.

In combination with thinning there was a sudden improvement of the light regime, enabling ferns (not only *A. trichomanes*) to germinate, as light was the limiting factor. Various plants colonised the area independently, as all plants were in their adult phase when recorded in 1977. This first generation suffered damage after heavy rainfall at Pentecost 1979 (Bremer 1980a) as trench banks eroded. Other fern species also suffered losses but to a lesser extent than *A. trichomanes*.

Two subpopulations were monitored, designated as K 23 and L 72. At K 23, *A. trichomanes* thrived optimally, with 3 - 5 % of the light cast on the herb layer, surrounded by an open vegetation of ferns. There was thinning in 1993 with subsequent recruitment in 1994. The same process took place in 1999/2000. A sudden increase of light stimulates recruitment. Recruitment took place on eroded patches, often in a vegetation of *Fissidens bryoides (Pellia endiviifolia - Fissidens bryoides type*, related to the *Fissidentietum taxifolii*; Bremer 1999). At L 72 there was a major recruitment surrounding a founder plant at the beginning of the 1980s. By gap formation (due to a storm in 1990) there was a strong increase of the light fall and *A. trichomanes* became overgrown by *Rubus idaeus*, *Rubus flexuosus* and *Circaea lutetiana*. In order to monitor this site, these plants were clipped annually. Through this form of management the fern population did not fade away (without management it would probably have disappeared).

It is difficult to explain why *A. trichomanes* was and is rare in the Kuinderbos. During the same period *A. scolopendrium* increased in number to c. 13,000 specimens in 2002. Although *A. trichomanes* prefers the steeper trench banks, there are still numerous apparently suitable sites where it is absent. In its wall habitat, *A. scolopendrium* is also much more common than *A. trichomanes*.

The longevity of *A. trichomanes* appears to be restricted. Only a minor part of the population is older than 10 years. In contrast, in the Kuinderbos, some plants of *Polystichum setiferum* are more than 25 years old. *Polypodium vulgare* (L.) Kuhn) is also long-lived, while clones of *Pteridium aquilinum* L. can live for centuries (den Ouden 2000). In plant nurseries ferns can be fertile within a year after sowing but in the field this takes longer.

In The Netherlands three populations were monitored for a long period (Amsterdam, Utrecht and Kuinderbos). The parameter of IJnsen seemed to be correlated with the population change per year. Severe winters have a significant impact on these populations, although necrosis could not be assessed. In moderate winters frost does not have any impact. *Asplenium scolopendrium* is much more sensitive under the same circumstances. In this species there was necrosis indicating damage even in moderate winters. Bremer et al. (1984) showed differences between these species in phospholipid content in winter, probably correlated with sensitivity to frost.

The terrestrial sites with *A. trichomanes* can be sustained when there is an extensive thinning management in the *Picea sitchensis* stands; this means thinning every 7 - 10 years, and governed also by the coverage of the herb layer. By cutting ca. 20 % of the trees at the same time, the canopy can recover in some years, restoring the light climate to 3 - 5 % of the incoming light reaching the herb layer. With a light fall of more than 5 %, *Urtica dioica* and *Rubus spp.* can invade and out-compete rare fern species. For the future, both subpopulations will be managed as described above. *Picea sitchensis* is an exotic tree species. Without any human interference, the species will be replaced over time by *Acer pseuoplatanus* and *Fraxinus excelsior* and at some sites even by *Fagus sylvatica*.

As the area with *Picea sitchensis* is decreasing there is a possibility that *A. trichomanes* will disappear from the area. However, as the trench habitat will survive these changes and the pH of the fine grained sand will be sustained, there will always be a chance of spontaneous (re-)establishment of *A. trichomanes*.

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NEW RECORDS FOR PUERTO RICAN PTERIDOPHYTES

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Key words: Puerto Rico, ferns, Caribbean, floristics

ABSTRACT

During a 2001-2002 collecting trip to Puerto Rico, eleven pteridophytes were collected that are Puerto Rican município records. Of the 11 collections, one is a Puerto Rican endemic *Selaginella*. For each specimen, we provide full collection data and previously known Puerto Rican distributions for the species.

INTRODUCTION

In late December 2001 through early January 2002, we collected eleven pteridophytes that are Puerto Rican município records. Previous Puerto Rican distributions for these taxa were obtained from Proctor (1989) and Barcelona (2000). Of the 11 taxa we collected, one was a Puerto Rican endemic (*Selaginella krugii* Hieron.) previously found in only four municípios. Alternatively, six common pteridophytes were recorded for the first time from Sabana Grande, suggesting that this area may have been overlooked by pteridologists in the past. The following records are arranged phylogenetically by family.

RESULTS

***Selaginella krugii* Hieron.** **Selaginellaceae**

RECORD VOUCHER: Puerto Rico, Município de Jayuya, growing under the shade of tree ferns and other plants in moist soil in the forest on the north side of Rt. 143 near km 16.2, 29 December 2001, *M. S. Barker #144 and S. W. Shaw* (MU).

PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Cayey, Ceiba, Naguabo, and Rio Grande.

GENERAL DISTRIBUTION: Endemic to Puerto Rico.

***Cyathea andina* (Karst.) Domin** **Cyatheaceae**

RECORD VOUCHER: Puerto Rico, Município de Jayuya, growing in moist soil beside roadway in medium to full sun along Rt. 143 approximately 11 km north of Rt. 10, 1 January 2002, *M. S. Barker #204 and S. W. Shaw* (MU).

PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Adjuntas, Arecibo, Maricao, and Orocovis.

GENERAL DISTRIBUTION: Hispaniola, Puerto Rico, and South America.

***Odontosoria aculeata* (L.) John Smith** **Lindsaeaceae**

RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing in full sun on rocks near a rock wall beside Rt. 120 just past km marker 9, 30 December 2001. *M. S. Barker #167 & 168 and S. W. Shaw* (MU).

PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Aguas Buenas, Barranquitas, Bayamon, Caguas, Cayey, Fajardo, Maricao, Mayaguez, Naguabo, Patillas, Rio Grande, San German, San Juan, Utuado, and Villalba.
GENERAL DISTRIBUTION: Greater Antilles (except Jamaica), St. Thomas, St. John, and Tortola.

***Adiantum capillus-veneris* L.** **Adiantaceae**
RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing on a shady, moist rock wall next to Rt. 120 past km 9. Found intermixed with *Polypodium polypodioides* var. *polypodioides* (L.) Watt, 30 December 2001, *M. S. Barker #169 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Coamo, Guayanilla, Salinas, and San Juan.
GENERAL DISTRIBUTION: Cosmopolitan in tropical, subtropical, and warm-temperate regions.

***Adiantum pyramidale* (L.) Willd.** **Adiantaceae**
RECORD VOUCHER: Puerto Rico, Município de Maricao, growing along a partly shaded roadside in moist serpentine derived soil beside a small waterway along Rt. 120 near km marker 113, 30 December 2001, *M. S. Barker #172 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Adjuntas, Aguas Buenas, Arecibo, Barranquitas, Bayamon, Cayey, Coamo, Guayanilla, Guaynabo, Gurabo, Isabela, Mayaguez, Naranjito, Quebradillas, Toa Baja, Utuado, Vega Alta, Yabucoa, and Yauco.
GENERAL DISTRIBUTION: Greater and Lesser Antilles.

Thelypteris hispidula* (Decne.) Reed var. *hispidula **Thelypteridaceae**
RECORD VOUCHER: Puerto Rico, Município de Jayuya, growing on the side of Rt. 143, north of 10, ca. 11km near the edge of the forest in moist soil in full to medium sun, 1 January 2002, *M. S. Barker #206 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Corozal, Maricao, and San German.
GENERAL DISTRIBUTION: Greater and Lesser Antilles, Tobago, Trinidad, continental tropical America from Mexico to Bolivia, tropical Africa, and Malesia.

***Blechnum occidentale* L.** **Blechnaceae**
RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing among grasses at the edge of a cliff in full sun along Rt.120 just past km marker 9, 30 December 2001, *M. S. Barker #171 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Adjuntas, Aibonito, Arecibo, Barranquitas, Bayamon, Cabo Rojo, Caguas, Cayey, Guayanilla, Guaynabo, Gurabo, Las Marias, Luquillo, Maricao, Mayaguez, Naguabo, Naranjito, Ponce, Quebradillas, Rio Grande, San German, San Juan, Trujillo Alto, Utuado, Vega Alta, Yabucoa, and Yauco.
GENERAL DISTRIBUTION: Widespread in tropical and subtropical areas from Florida to Argentina.

***Phlebodium aureum* (L.) John Smith** **Polypodiaceae**
RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing in full sun on rocks near a rock wall along Rt. 120 close to km marker 9, 30 December 2001, *M. S.*

Barker #166 and S. W. Shaw (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Adjuntas, Aibonito, Barranquitas, Bayamon, Cayey, Dorado, Isabela, Juana Diaz, Manati, Quebradillas, Rio Grande, Salinas, and Yauco.
GENERAL DISTRIBUTION: Florida, Bahamas, Greater Antilles, Lesser Antilles, Trinidad, and continental tropical America.

***Pleopeltis polypodioides* (L.) E. G. Andrews & Windham** **Polypodiaceae**
RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing on a shady, moist rock wall adjacent to Rt. 120 past km 9. Found intermixed with *Adiantum capillus-veneris* L., 30 December 2001, *M. S. Barker #165 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Adjuntas, Aibonito, Arecibo, Barranquitas, Bayamon, Cayey, Ciales, Isabela, Juana Diaz, Maricao, Ponce, Vega Alta, Villalba, Yabucoa, and Yauco.
GENERAL DISTRIBUTION: Bahamas, Greater Antilles, Cayman Islands, Lesser Antilles, and continental tropical America from Mexico to Costa Rica and Venezuela.

***Polypodium sororium* Humb. & Bonp. *ex* Willd.** **Polypodiaceae**
RECORD VOUCHER: Puerto Rico, Município de Sabana Grande, growing on a well shaded, moist rock wall along Rt. 120 near km marker 9, 30 December 2001, *M. S. Barker #170 and S. W. Shaw* (MU).
PREVIOUSLY KNOWN PUERTO RICAN DISTRIBUTION: Aibonito, Guaynabo, Maricao, Naguabo, Patillas, Rio Grande, and San Lorenzo.
GENERAL DISTRIBUTION: Greater and Lesser Antilles, and continental tropical America.

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BARCELONA, J. 2000. Systematics of the fern genus *Odontosoria sensu lato* (Lindsaeaceae). Ph.D. dissertation, Department of Botany, Miami University, Oxford, Ohio.

PROCTOR, G. R. 1989. Ferns of Puerto Rico and the Virgin Islands. Mem. New York Bot. Gard. 53: 1-389.

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STEVENSON, D.W. & LOCONTE, H. 1996. Ordinal and familial relationships of pteridophyte genera. In: CAMUS, J.M., GIBBY, M. & JOHNS, R.J. (Eds) Pteridology in perspective, pp. 435-467. Royal Botanic Gardens, Kew.

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